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Step-by-Step Intertoll Dialing

By R. E. KING
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THE operator at an "inward" toll switchboard may be required to complete calls either to local dial or manual offices or to outlying tributary offices. Some of these arrangements are indicated in Figure 1. For handling calls to dial offices she has either a dial or a key set with which she dials or "key pulses" the number wanted after plugging in to the proper trunk jack. When she extends a call to a manual office reached over a straightforward trunk, a lamp lights automatically at the distant office to attract the operator's attention. When she extends a call to a manual office that is reached over a ringdown trunk, however, she must ring over the trunk in order to attract the attention of the distant office.

In converting toll trunks so that the originating toll operator can dial directly a subscriber in a dial office at the distant end, the operator's core circuits at the inward toll board are replaced by selectors of the step-by-step type, giving an arrangement as shown in Figure 2. Each incoming toll trunk has an intertoll first selector associated with it, and by dialing any digit from 2 to 9 inclusive, the originating operator selects the office desired, either dial or manual, in the local area. Should there be more than eight offices, second selectors will be added. These selectors act as the first, or first and second selector in a local dial office, and give access to all numbers that are employed in that numbering area.

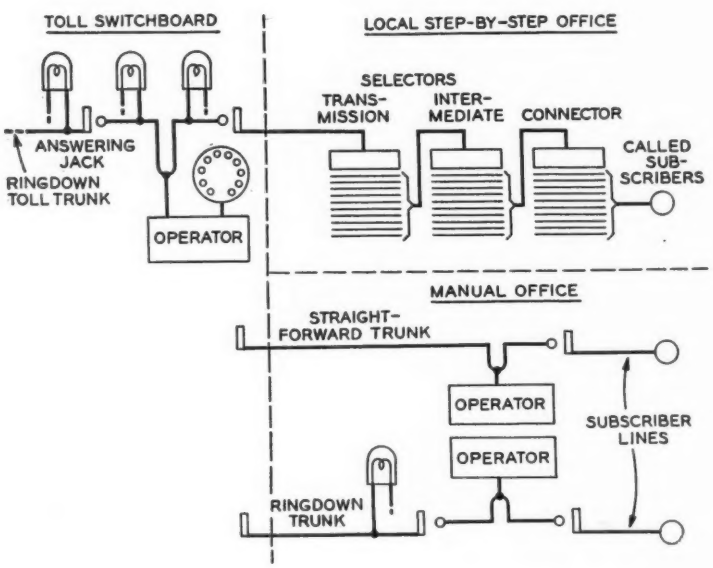


Fig. 1—Simplified schematic of arrangements for handling incoming toll calls at a manually operated board

For tributary manual or dial offices, an auxiliary first selector is used, which is reached from the first level of the intertoll first selector. Since such offices are not numbered in the series of local offices, they may be assigned a two-digit number between 11 and 19—the first digit indicating the first level of the intertoll selector, and the second, one of the levels of the auxiliary selector. Here, also, the

second selectors may be added if necessary. Operators at the toll board are also reached through this auxiliary first selector. All of the operator trunks connected to this selector signal the distant operator automatically when they are seized.

When the office desired is reached over a ringdown trunk terminating in a jack at the remote switchboard, an auxiliary second selector is required to provide the two-second ringing needed. This selector is reached through equipment that provides two-second ringing, and trunks from it generally have a three-digit number. Although the trunks are shown arranged for one-way service, they may be arranged for two-way operation when conditions make it economical to do so.

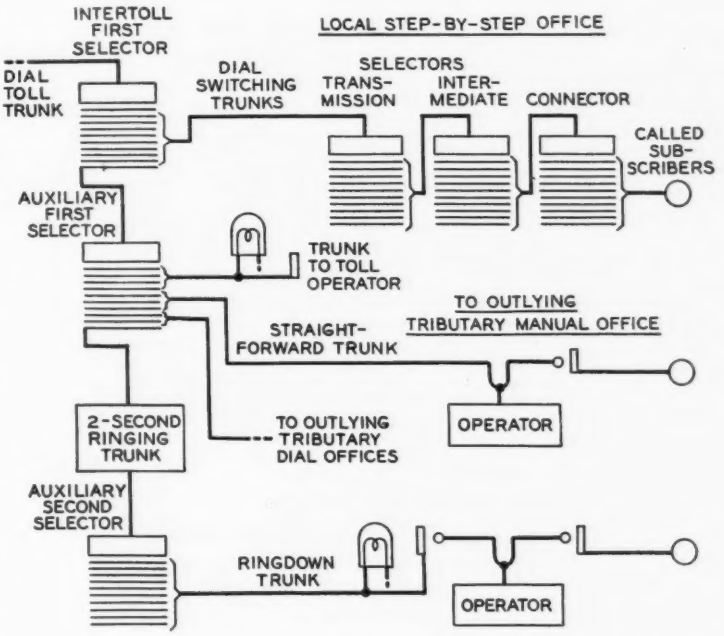


Fig. 2—In converting to dial operation, the operator's cord circuits are replaced by step-by-step selectors

The pulses sent over the toll trunk for operating the step-by-step selector and those that return the supervisory signals to the originating operator flow over a composited circuit as already described.* This composited circuit terminates in a CX relay at the toll office. This relay is used to send out the pulses that operate the intertoll selector, but the usual local type of dialing circuit cannot satisfactorily be used because line balance must be maintained to meet the requirements of repeatered toll circuits. To avoid disturbing this balance, a simplex pulsing circuit is provided for transmitting the pulses and signal through the central office.

The circuit used is shown in simplified form in Figure 3. On an incoming call, the CX relay follows the pulses, opening and closing a ground connection to the simplex circuit, in which the current flows equally and in the same direction over both sides of the line. This circuit is connected to battery through the A relay, which follows each pulse and steps the selector up to the desired vertical level. Here the switch hunts horizontally until it finds an idle trunk, at which time the D relay operates and connects the two toll trunks together. The next set of pulses then flows through the selector contacts and the retard coil in the outgoing toll trunk to the pulsing relay, which by alternately connecting the mid-point of the CX1 relay to ground and battery sends the pulses over the composite circuit to the distant office. In the meantime a supervisory circuit

*RECORD, *July*, 1940, *p.* 337.

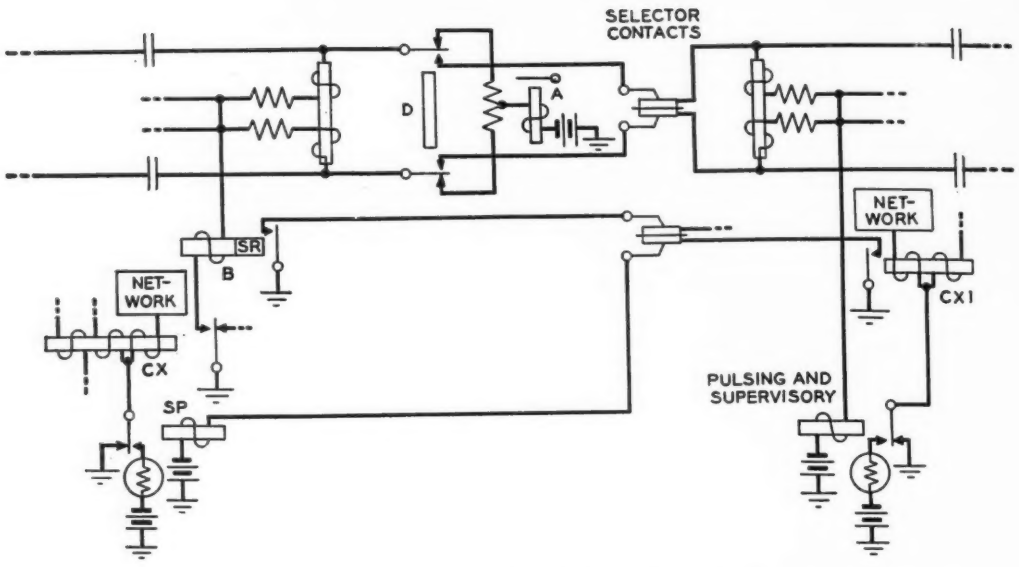


Fig. 3—Simplified schematic of simplex pulsing and signaling in the toll office

has been set up from relay CX1, through the selector contacts, and to the SP relay, over which signals may be returned to the originating operator.

An important feature of repeatered toll trunks is the control of gain by pads. When two toll trunks are connected together, these pads are cut out to increase the gain. When a toll trunk is connected to a subscriber, through a switching trunk, the pads must be left in the circuit to reduce the gain, because these local circuits are not balanced with sufficient accuracy by the balancing networks to permit the greater gain. Also the greater gain is not needed because of the comparatively short length of the circuit.

On manual toll trunks this pad control is secured by a circuit shown on Figure 4. When two toll trunks are connected together, the two P relays are in series to ground on each side, so that they release and operate their P1 relays, which short circuit the series resistances of the pad and open the shunt resistances. When the toll trunk is plugged into a switching trunk,

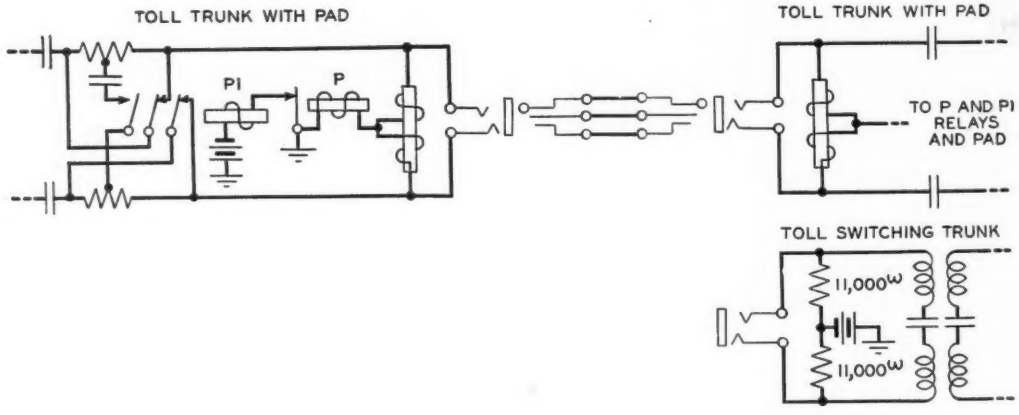


Fig. 4—Arrangements for pad control in manual toll offices

however, a high-resistance battery connected to the simplex circuit in the switching trunk operates the P relay which in turn releases the PI relay and connects the pad.

In adapting these circuits for intertoll dialing this arrangement cannot be used because the ground associated with the P relays would operate the pulsing relay. By a modification shown in Figure 5, however, this difficulty is avoided, while still securing the proper action of the P and PI relays. Instead of connecting the winding of the P relay in the simplex circuit to ground, it is connected across the line through the retard coil and thus will not operate on simplex current. The ground is obtained from the CX relay through two balanced resistances. In the outgoing toll trunk, the battery operating through the pulsing relay is similarly connected through balanced resistances. When these two trunks are connected together, no current will flow through the winding of P because it is connected across equipotential points of the circuit from battery on the pulsing relay to ground on the CX relay.

The resistances through which the pulsing relay is connected to the retard coils on switching trunks, however, are not balanced, one being larger than the other. When the toll trunk is connected to such a trunk, therefore, the points across which the P relay is connected are not at the same potential because of the unbalanced resistances ahead of it. As a result, a current will flow through P and operate it. This will open the circuit to PI, and the pad will be connected into the circuit.

The above intertoll dialing circuits, which provide all the features necessary for toll operation, can be installed in any step-by-step area, and can be used in conjunction with existing toll plant and switchboards.

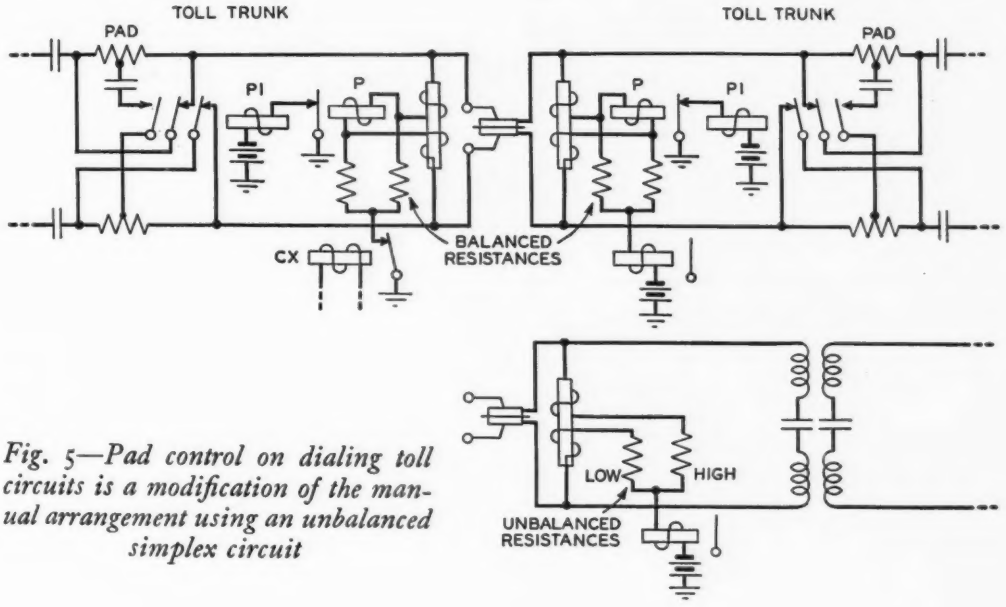


Fig. 5—Pad control on dialing toll circuits is a modification of the manual arrangement using an unbalanced simplex circuit

Aerial Cable Lashing Machine

By E. ST. JOHN
Outside Plant Development

IN AN improved method of aerial cable construction, now coming into general use, the cable is bound to its supporting strand with a spiral wrapping of soft steel wire which is applied by a machine. This contrasts with the former procedure of suspending the cable from the strand with uniformly spaced wire rings. The cable and strand are lashed together so securely that there is little relative motion to cause abrasion of the cable sheath by the strand.

In the history of aerial cable, which began to supplant open-wire telephone lines about sixty years ago, there are various methods of suspension. What was desired were reasonably durable supports which were inexpensive to install. Those used in the 1880's included canvas slings, loops of marlin or of wire and sheet metal clips as well as spiral wrappings of wire or marlin. During this period a machine was developed to lash cable to its strand by applying a spiral wrapping of marlin, but the device was not widely used after the early nineties.

From the beginning of the nineties until about 1915, aerial cables were supported by marlin ties, metal hangers of various designs and sheet metal rings which were crimped to the strand. Then came rings made of spring steel wire which were snapped onto the strand by hand and provided stiff and firmly positioned loops to support the cable. This effected considerable economy in placing cable and also provided supports which had long life because of their galvanized coating. After several years of trial, however, it was found that this type of construction resulted in some sheath failures.

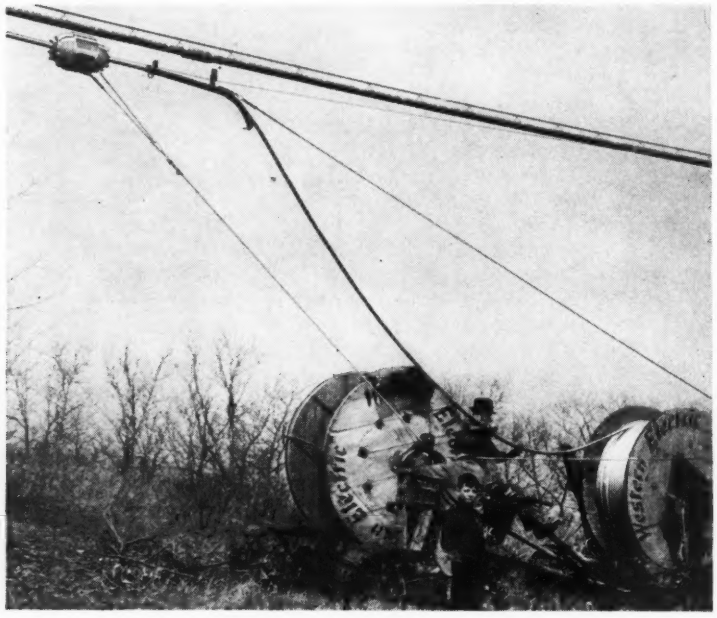


Fig. 1—Cable-reel trailers and a tractor are used for lashing cable to the strand directly from the reel

Studies of these sheath failures* disclosed that the supporting rings were cutting into the lead covering and ultimately causing breaks

*Page 273 of this issue.

which admitted water. The severe ring cutting usually happens at or near poles. This condition has been considerably alleviated in recent years by placing the strand with more sag; by adding protective cable shields at certain points; by clamping the cable to the strand at points; and by using cable supports which grip the cable but swing freely on the strand.

Recently the idea of lashing cable to strand was taken up again because it minimizes the relative motions between cable and strand while providing a support neater in appearance than ring suspension. The method is now feasible because steel wire has become available which carres a zinc coating heavy enough to resist rust but still flexible and adherent. The lashing machine, which in shape looks like an electric motor, is enclosed in an aluminum housing about nineteen inches long and weighs about forty-five pounds. It rides along the strand on trolley wheels within its housing and can be pulled from one pole to another pole in a few minutes by a rope from the ground.

The machine has a drum-shaped middle section and dome-shaped ends. The drum section rotates and, as the machine moves forward, it carries a small reel of lashing wire around both cable and strand. These combined rotary and forward motions of the reel lash the cable and strand together with a spiral wrapping. The rotating drum is equipped with a counterweight to balance the reel of lashing wire, and also with a grooved pulley around which the outgoing wire is led to provide suitable back tension. When viewing the machine in operation, the assembly of cable and strand seems to be passing through the center line of the apparatus.

Adjustable cable-lifting rollers and

Fig. 2—A telephone lineman dead-ending the lashing wire at the pole. The lashing machine is shown at the left and is in position to begin lashing the next span of the cable

the pulling attachments are secured to the dome-shaped ends of the machine. Each end contains a grooved rubber driving wheel, which rolls along the strand and turns the rotating drum through a pair of gears, and a rubber friction wheel. The cable-lifting mechanisms are horizontally positioned rollers and can be set at the desired height to raise the cable so that it approximately touches the strand. The pulling attachments merely provide means for attaching a rope.

No practical type of lashing machine and strand attachment has yet been visualized which will permit the device to ride past a pole. Consequently the machine has been de-

signed so that it can be readily removed from the strand or replaced. This is done by swinging the hinged cable-adjusting rollers out of the way and then rotating the drum until its cut-out section is directly below the strand and cable. Easy reloading with a new coil is provided by a hinged gate on the rotating drum. The lashing wire is furnished in 350-foot lengths which are wound in flat coils seven inches in diameter.

When field conditions permit, it is preferable to lash the cable directly from the reel to the strand. The prevalence of trees and other aerial structures, and the fact that aerial cable is usually installed on the field side of the pole, frequently make it necessary, prior to lashing, to install the cable in the usual way, but with widely spaced temporary rings. These temporary rings are then replaced with sliding rings or marlin ties which are pushed along by the machine as it lashes the cable. When lashing directly from the reel to the strand one of these machines will secure from one to three miles of cable in a day. By the other method, it has been found that a mile to a mile and a half of cable can be lashed daily.

Originally proposed by the Southwestern Bell Telephone Company, the idea of a machine which would lash cables to strand by wire was tried out with models built by that company and later by the Laboratories. Experience with these early models resulted in the present design.

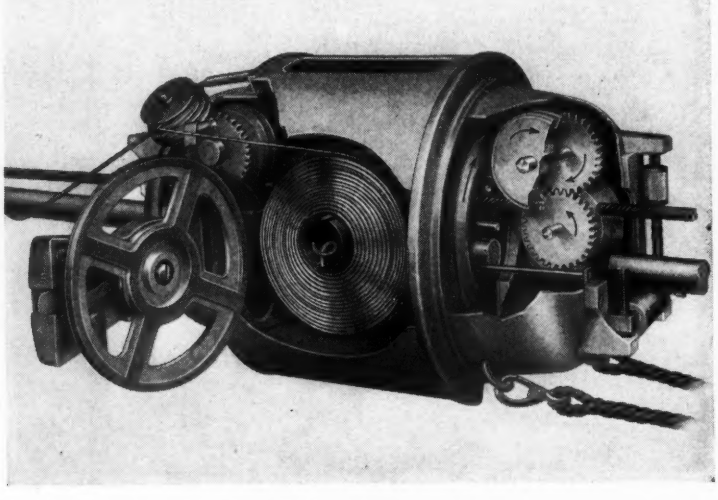
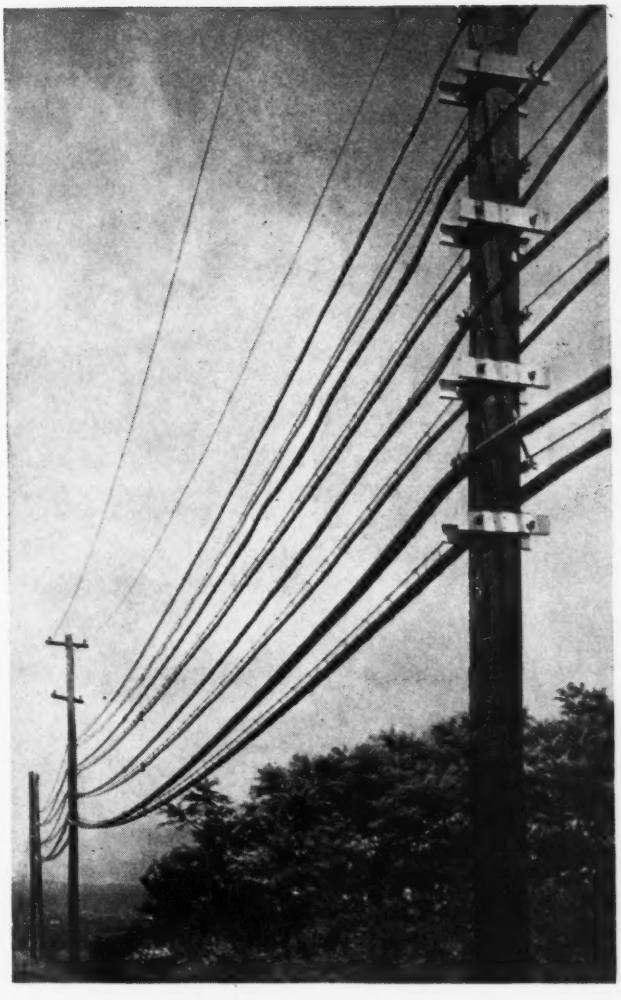


Fig. 3—The central drum-shaped portion of the cable-lashing machine revolves on rollers. It is driven through bevel rings by beveled rubber wheels which are geared to grooved rubber wheels that roll along the strand. The reel and feeding mechanism for the wire are located on one side, counterweighted by a block of lead on the other side of the revolving drum

Lashed Aerial Cable

By J. A. CARR
Outside Plant Development



SINCE a telephone cable is no better than its sheath, any deterioration of cable sheath is of vital importance. In aerial cables, hung in rings according to conventional practice, it has been found that many sheath failures are due to the effect of temperature changes on the length of the cable. To overcome this, a new system of suspending cables has been developed* wherein the cable is lashed directly to its supporting strand by a machine-applied wire serving. In connection with this development, studies have been made to compare the lashed method with ring suspension and to determine the most suitable arrangements in the details of lashing the cable.

An aerial cable is relatively straight throughout the span but is definitely bent at the junction of two spans. At that point, further bending will readily take place if the cable expands lengthwise. Expansion occurs whenever the cable is heated by the sun. Most of it is taken up by further deflection of the cable at the pole when the cable is hung in rings. Often this has undesirable results: bows or sharp reverse bends are produced, in which the sheath may be severely worked; even relatively low stresses, if slowly but repeatedly applied, develop in lead alloy sheath the crystalline changes which eventually cause cracks. The coming and going of the bows may also contribute to abrasion of the sheath where it bears against the rings; these abrasions or "ring cuts" become weak points which further concentrate the bending until stresses are above fatigue limit.

In studies to compare the performance of lashed and ring supported cable, outdoor tests were undertaken at the Chester field laboratory. These tests covered a range of cable sizes and strand tensions and employed various methods of terminating the lashing wire and supporting the cable at poles, splice points and

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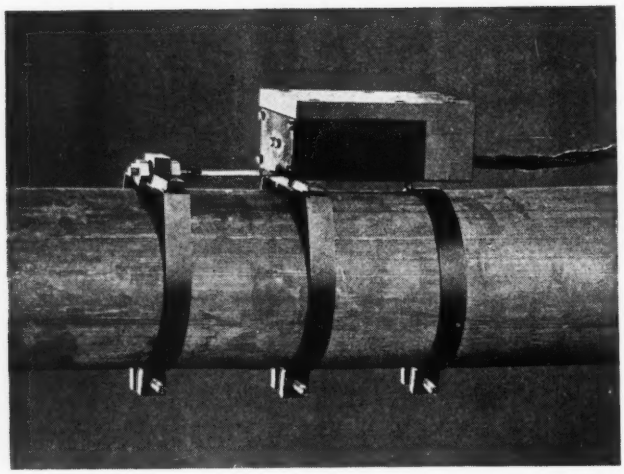


Fig. 1—Strain gauge tests show that the slow expansion and contraction of the cable caused by daily temperature changes, rather than vibration, are responsible for the sheath strains which produce cracks*

terminals. In checking the effect of these variations, observations were made of bowing and of the tendency for cables to abrade when mechanically swung in a manner simulating movement in wind. Strains in the sheath produced by temperature changes were also measured precisely by strain gauges located at different positions along the cable.

The strain gauge and fatigue experiments confirmed previous studies which indicated that the slow expansion and contraction of a cable, caused by daily temperature changes, are responsible for the large sheath strains which produce fatigue and sheath cracks, rather than rapid vibrations caused by road traffic or wind sway. The largest strains were found on the bottom of the cable at the pole and the larger sizes of cables developed greater strains in rings than did similar lashed cables. The strains at the pole in lashed cable of the smaller sizes are somewhat greater than for such cable in rings, but are not of serious proportions.

When low strand tensions were used, less bowing occurred, both on ring-supported and on lashed cable. Under this condition thermal expansion increases the length of the strand more than it would if it were highly tensioned, so that the differential to cable expansion is reduced.

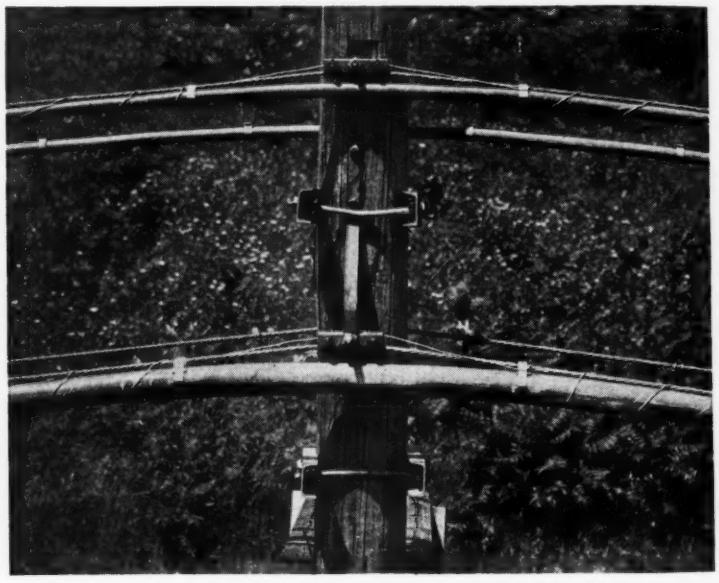


Fig. 2—To prevent abrasion at the pole during the swing tests the lashing was stopped about fifteen inches from the pole and the strand and cable were bound together by an aerial cable support at that point. The lashing wire passed through the eye of the support. On large cable a lead spacer was inserted between the strand and cable at the support to prevent abrasion beyond the cable support. The middle cable is supported by the conventional rings and aerial cable supports

*RECORD, *Feb.*, 1940, *p.* 161.

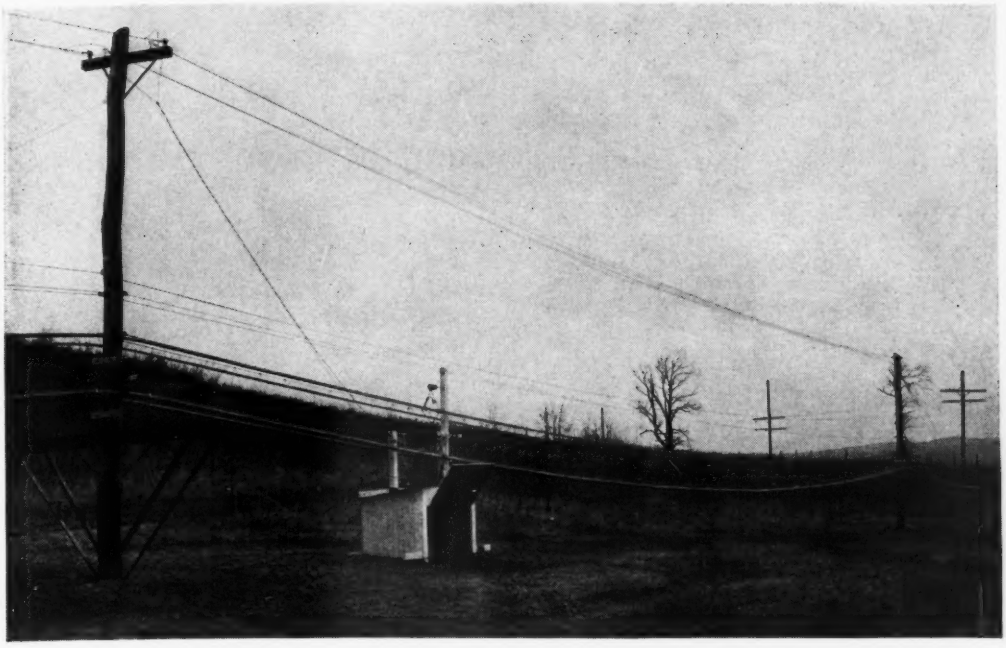


Fig. 3—Spans were swung day and night to accelerate abrasion

Lashing has a snubbing effect which confines the expansion of cable to minor waves throughout the span instead of permitting movement of the excess cable into the bent section at the pole with the formation of bows.

In the swing tests, two or more cables in one span of a line are swung mechanically day and night to accelerate the abrasion that would occur between cables and their supports in normal service. Of the various conditions tested, the one which resulted in the least abrasion omitted the lashing wire in a section near the pole. At a point about fifteen inches from the pole, strand and cable were bound together by an aerial cable support as shown in Figure 2. Through the support, the lashing wire was terminated after tapering off the lay by hand from around fourteen inches, as served by the machine, to about three or four inches. Thence the wire was extended along the strand to a point above and back of the suspension clamp and terminated by connection to the wire from the adjacent span. The aerial cable support as modified above is known as "lashed cable support." With this arrangement the lead shield, otherwise required to keep the cable from bearing against the suspension clamp, was omitted. Obviously no abrasion of the sheath occurred in the unsupported section at the pole but on the large cables some abrasion resulted from contact with the strand just beyond the lashed cable support. It was found that separating these cables from their strand a quarter of an inch at the cable support with a lead spacer prevented abrasion for several inches towards the center of the span. This also permitted the cable to follow a bend of larger radius at the junction of two spans, reducing strains due to temperature changes. Even with this arrangement, swinging produced abrasion of the sheath at scattered points throughout the span where cable

larger than about one and three-quarter inches in diameter pressed against the strand in bending under longitudinal expansion.

While this abrasion along the span seems to develop somewhat more rapidly than corresponding ring cuts in a comparable cable, the injuries are

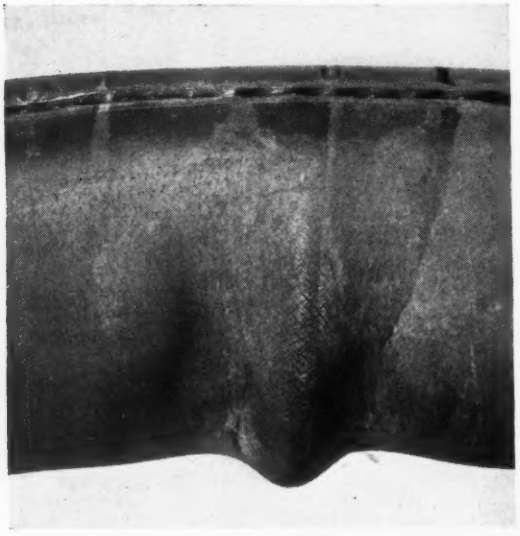


Fig. 4—Compression failure on a cable sheath caused by bowing experiments at the field laboratory at Chester, New Jersey. The longitudinal cut at the top was made in removing the sheath from the cable

at points not subjected to severe bending and, being longitudinal, they are not expected to be serious.

The studies at Chester have been extended to include conditions associated with corners, strand connectors, cable splices, terminals and loading coil cases, each of which was found to require some special treatment for the best results.

At the time of lashing, it is important that any excess length of cable due to waviness be removed, especially in the case of small cables; otherwise definite bowing is likely to occur. A tubular cable straightener has been found useful for this purpose.

These studies indicate that attention to the following construction features is important to obtain favorable maintenance conditions for lashed cable. The strand tension ought to be low and some tension should be applied to the cable during lashing to assure removal of the slack. To avoid abrasion at the poles there should be a self-supporting section of cable without lashing and a spacer between the cable and strand at the supports, for cables larger than about one and one-half inches in diameter.

From an appearance standpoint the straightness and compactness of a lashed cable assembly make both large and small cables less conspicuous and more sightly than when ring supported. The flexibility of small

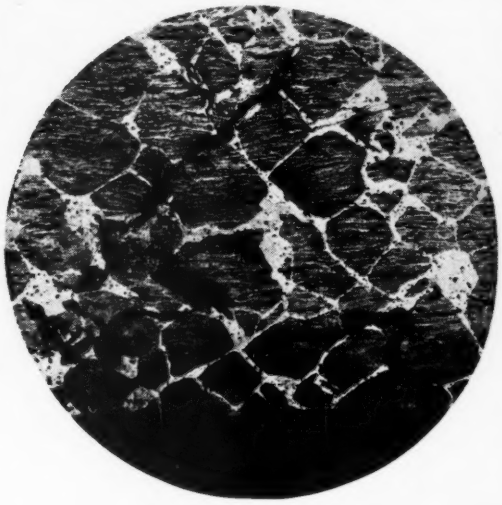


Fig. 5—Photomicrograph showing cracks and structural changes produced in standard lead-antimony cable sheath by aging and the fatigue forces acting at a bow

cables makes it practicably impossible to keep them straight in rings as usually spaced but when snugly lashed they must necessarily conform closely to the alignment of the strand. This feature alone provides a strong appeal for lashed construction.

Measuring System for Carrier Circuits

By S. ROSEN
Transmission Development

HIGH-FREQUENCY pilot currents are transmitted over type-K carrier telephone lines and measurements of their levels are made periodically to indicate the performance of the circuit over the transmitted band from 12 to 60 kc. A transmission measuring system, coded 42A, has been designed to measure the levels of these currents. With it measurements can be made at any frequency in the type-K range, not only of pilot currents, but also of carrier leaks or of test tones when introduced into any one of the individual channels. The 42A system is installed at each attended repeater station and can be used while the carrier circuits are in service; this is especially important on carrier systems because an interruption of one line affects many voice channels. Essentially the system is a heterodyne detector designed to be bridged across the line. The input signal is modulated to an intermediate frequency, selected by a crystal filter, brought down to one kc in a demodulator and applied to a thermocouple measuring set.

Transmission loss due to bridging the measuring set across the line is made less than one-tenth db by a high-impedance pad, Figure 2. This pad also keeps extraneous currents, which originate in the measuring system, from being fed back into the line in appreciable amount.

The circuits of the modulator and demodulator, which are essentially identical, have a double balanced arrangement of copper-oxide varistors, Figure 1, and a pad at the output side to present a constant impedance to all the modulation products. This gives a flat frequency-transmission characteristic and aids in obtaining stabilized operation. A modulator of this type is practically independent of variations in the level of the carrier supply, over a limited range, and changes in room temperature also produce very little effect. The modulator and a demodulator operate with a nominal carrier-supply level of ±16

dbm (db referred to one milliwatt) at an impedance of 20 ohms. A 17B oscillator* provides the carrier supply to the modulator and can also serve as a test oscillator for general office maintenance.

At the mid-band frequency of 130 kc the 95A crystal filter has a pass band of about 20 cycles. As shown in Figure 3, its attenuation at frequencies 100 cycles away from 130 kc is about 30 db. This permits the pilot currents located at 15.9, 27.9 and 55.9 kc to be measured and distinguished from the carrier leaks at 16, 28 and 56 kc, whose amplitudes may be comparable to the pilot currents. A mid-band frequency of 130 kc was chosen because the carrier supply required by the modulator of the measuring system varies with this frequency from 70 to 118 kc for any line signal in the range from 12 to 60 kc. Accordingly, any carrier leaks or other unwanted frequencies from the modulator which are fed to the line would fall outside of its transmitted band. Extraneous frequencies from the modulator are suppressed by the band filter and prevented from affecting the measuring circuit. The frequency selected is also within the operating range of the type-K transmitting amplifier which, with minor modifications at the input, is used for the test amplifier. The measuring system has a nominal gain of 63 db with a fairly flat response over the range from 12 kc to 130 kc.

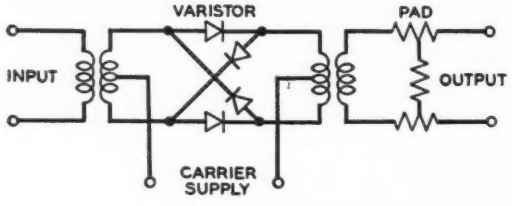


Fig. 1—Circuit of either the modulator or demodulator of the 42A transmission measuring system. Two steps of modulation are employed in this selective heterodyne detector designed to be bridged across the line

Carrier is supplied to the demodulator by a 50B oscillator whose circuit is shown in Figure 4. It is a single-frequency oscillator with crystal control which maintains its output at 129,000 ± 50 cycles; its maximum output is +17.5 dbm at 129 kc. The 130 kc signal is modulated by this frequency to one kc so that it may be measured readily or observed aurally. To match the input impedance of the demodulator, the output impedance of the oscillator is made 20 ohms. An output level adjustment sets the carrier supply level to +16 dbm. The

*RECORD, *May*, 1939, *p.* 291.

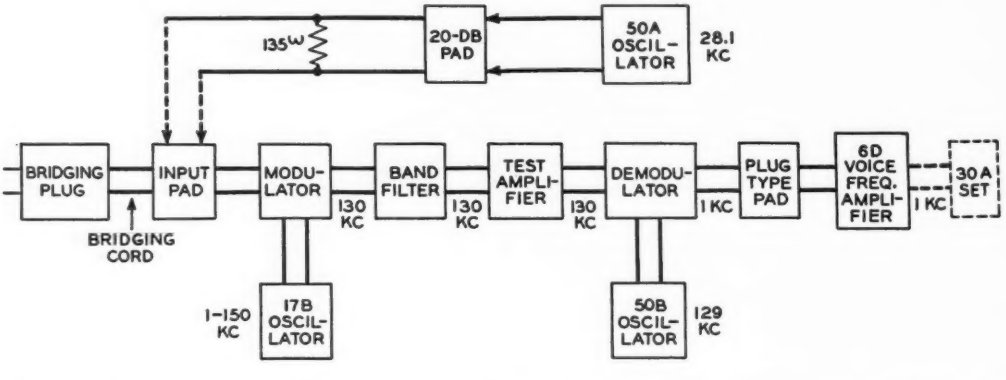


Fig. 2—Block schematic of the 42A transmission measuring system as used for measuring pilot levels on type-K carrier telephone circuits

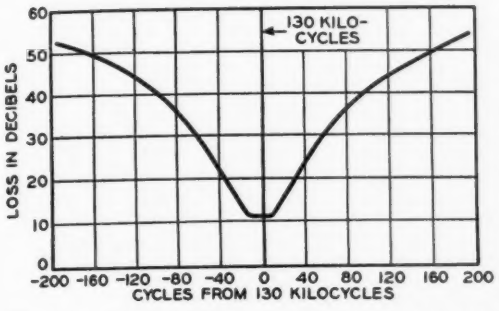


Fig. 3—Loss-frequency characteristic of the 95A *filter of the transmission measuring system. This filter passes a narrow band at* 130 *kc and eliminates all but the signal*

tuning condenser varies the frequency of the tuned circuit to that of the crystal, at which point the crystal takes control. A minimum reading on the plate-current meter indicates this control point.

Standard resistances which plug into a 1C pad are used to attenuate the output of the demodulator. Values from zero to nine db are available and the one chosen for any particular office is that equal in db to the nominal gain from the transmitting toll switchboard to the point where the measuring set is used.

A simple low-pass filter at the input of the 6D voice frequency amplifier circuit (Figure 2) suppresses the upper side bands from the demodulator. This amplifier has a single stage and uses cathode feedback for stabilization, as shown in Figure 5. Gain control over a range of 23 to 30 db, obtained by varying the feedback resistance, is used to calibrate the overall measuring circuit. The transmission characteristic of the amplifier is practically flat from 500 to 1500 cycles and then drops off rapidly at both ends. This characteristic approximates that desired for observing noise or interference on a circuit. The amplifier has an output limiting characteristic to protect the thermocouple of the 30A set from being burned out by overloads. For outputs up to +5 dbm the input-output characteristic of the amplifier is linear. Beyond that point it increases at a continuously slower rate with increases in input to a limiting output level of about +11 dbm. No greater output can be obtained regardless of how much the input is increased. Normally the amplifier operates at an output of one milliwatt. To the output of the measuring system is patched a 30A trans-

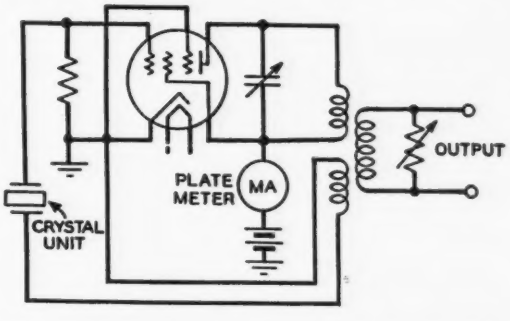


Fig. 4—Circuit of the 50B *oscillator which is crystal controlled and supplies the* 129*-kc carrier frequency for the demodulator of the transmission measuring system*

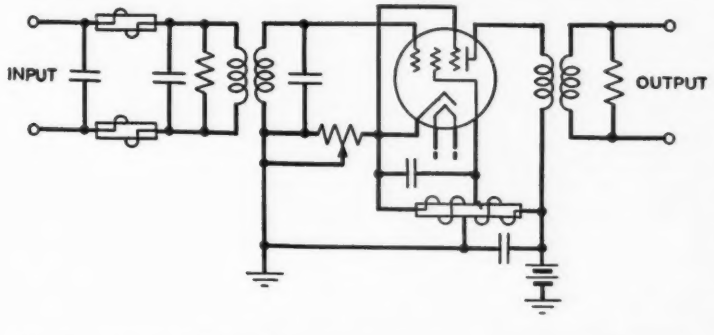


Fig. 5—Circuit of the 6D *voice-frequency amplifier. Variable feedback is used to control the gain in calibrating the overall sensitivity of the measuring system*

mission measuring set* and the reading of its meter plus the value of the plug type pad indicates the operating level of the circuit.

To calibrate the measuring system the output of the 50A oscillator, whose circuit is shown in Figure 6, supplies a test tone of 28.1 kc. This output is

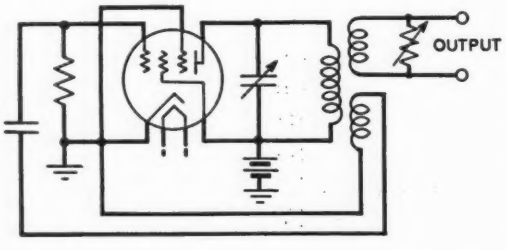


Fig. 6—Circuit of the 50A oscillator. The output of the oscillator is adjusted to one milliwatt at 28.1 kc when calibrating the transmission measuring system

first adjusted to exactly one mw and then fed through a 20 db pad into the bridging pad as shown on Figure 2. Since the pilot currents are transmitted on the line at a level 20 db below that of the message channels, the calibrating signal thus applied represents a normal pilot at a zero level point. A zero loss pad is substituted for the plug type pad and the measuring system is adjusted to measure and indicate correctly the level of the applied calibrating signal by adjusting the gain of the voice frequency amplifier.

For measurements on a type-K system an adapter plug is inserted in the jacks through which the output of the office equipment is connected to the line. The normal connection through the jacks is replaced by a similar connection through the plug so that the circuit is not broken. There are two pin jacks at the back of the adapter plug into which the plug connected to the bridging cord of the 42A transmission measuring set can be inserted to bridge the measuring set on the line. The three pilot frequencies 15.9, 27.9 and 55.9 kc can be measured by setting the oscillator frequency at 114.1 kc, 102.1 kc and 74.1 kc, respectively. In addition to these measurements, a signal introduced on any one of the channels or produced in the line anywhere in the frequency range of 12 to 60 kc can be measured by adjusting the frequency of the 17B oscillator so that it modulates that signal to 130 kc.

Although the 42A transmission measuring system was developed primarily for use as a high impedance detecting circuit, its individual units or a combination of them find application in many other tests associated with circuit maintenance.

*RECORD, *Aug.*, 1939, *p.* 385.

NEWS AND PICTURES OF THE MONTH

With this powerful electromagnet, the permanent magnet of a polar telegraph relay may be restored to its full strength (*see page* vii)

News of the Month

National Defense and the Bell System

From a statement by President Gifford, at the Annual Meeting of Stockholders of the American Telephone and Telegraph Company, held on April 16, 1941.

"We of the Bell System are concentrating on doing well our part in our country's defense program, which in size and speed is undoubtedly the biggest job ever undertaken by any country. . . . New or enlarged Army and Navy camps, bases, aviation fields, and other military establishments together with Government-owned or financed plants making ordnance, aircraft and other war products where major telephone construction is involved, total about 600. This includes establishments planned, under construction and completed. We have finished substantial telephone installations at about 200 of these places and the facilities at the remaining places will be ready when needed. . . .

"While we are working at high pressure to give telephone service to the Army and Navy, and to provide other equipment for the two services, almost every other industry in the United States is also working on defense production. We have our part in that because as others increase the tempo of their efforts they inevitably use the telephone more and use more telephones, for the telephone is an instrument of speed and accuracy in modern affairs. And this means that we have a little part in almost every effort toward national defense. A little part in every effort adds up to pretty large figures.

The Murray Hill Laboratories, the appearance of which on April third is shown by this picture, are expected to be completed by the first of September and to be occupied by most of the personnel of 800 *by the end of the year. The structure in the right foreground and framework at the extreme right are the restaurant and the Acoustics Building which will contain a small Auditorium.*

The sixth annual photograph exhibit of the Press Photographers' Association of New York was held in the Museum of Science from March 29 to April 20. At the preview, which is shown above, F. B. Jewett, as president of the Museum, opened the program, the main feature of which was an address by Wendell L. Willkie. Approximately 800 photographs, representing the work of 90 press photographers, were on display

In commenting on problems of manufacture and materials Mr. Gifford said:

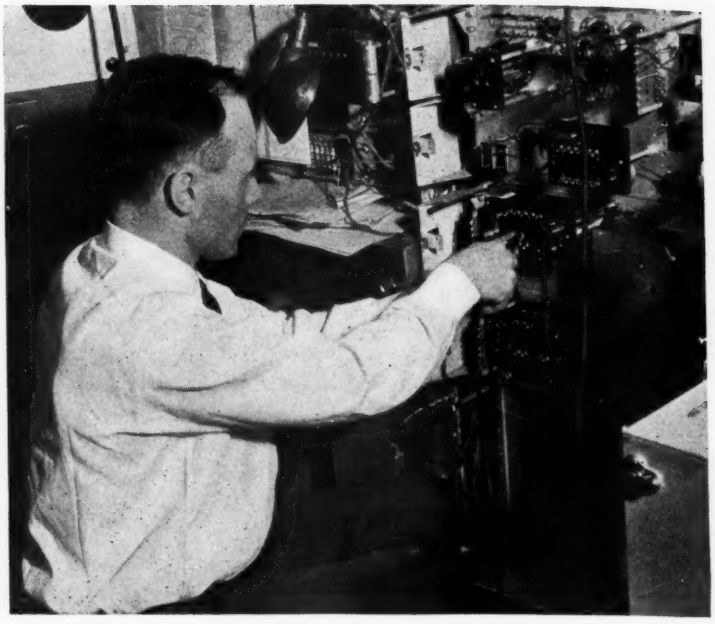
"Western Electric manufactures the equipment and materials needed by the Telephone Companies for their huge construction job. In addition it is furnishing directly to the Army, Navy, the air services and the Coast Guard, quantities of switchboards, cable, telephones, microphones, radio telephones, field sets, field wire, and other items of communication equipment. Moreover, Western's Specialty Products Division has already received Government orders for highly specialized communication equipment totaling approximately $40,000,000.

"We have had for some time a group, including representatives of the Bell Telephone Laboratories, Western Electric and our headquarters' staff, at work on substitutes for such critical materials as aluminum, nickel, zinc, and magnesium, all of which are used in the telephone apparatus. We have pledged to the Priorities Division of the Office of Production Management in Washington that we will make every effort to reduce our use of such materials even at some penalty in cost and effectiveness. It is not a simple matter, but we have already made some real progress and we hope to go further."

Intense Effort

The Laboratories have never been busier nor have so many of the departments at the same time been engaged in such intense efforts as are occasioned by the present necessities. Developments and engineering arising from the equipment needs of the Bell System and the rapidly increased manufacturing program of the Western Electric Company are receiving the fullest attention. The task of those concerned with these

strictly telephone projects has been rendered more difficult and has called for more effort because of the relatively large number of men who have been transferred or diverted to the problems presented by the Army, Navy and particularly the National Defense Research Committee. The pressure is felt by every department of the Laboratories and not least by the Staff and Service Departments without whose assistance the engineer is frequently helpless. From those engaged in purchasing to the Engineering Shop which skillfully and accurately translates drawings into finished apparatus, from the drafting rooms which design to the stenographic and other groups who record, there is no group that can be named that is not carrying a full and important load of rush work.



J. C. McCoy adjusting a pilot-frequency supply panel of the new equipment that is being installed for the New York-Philadelphia coaxial system

The defense projects themselves engage about 200 of the technical staff and call for proportionate activities by their assistants and by the Service Departments. In addition, the National Defense Research Council, of which Dr. Jewett is a member, is receiving on various of its sub-committees the services as consultants, and sometimes as chairmen, of the following members of the technical staff of the Laboratories:

J. A. Becker	O. B. Jacobs
Ralph Bown	K. G. Jansky
O. E. Buckley	M. J. Kelly
Harvey Fletcher	E. Lakatos
W. Fondiller	F. A. Polkinghorn
H. T. Friis	R. K. Potter
T. C. Fry	V. L. Ronci
C. H. Greenall	G. R. Stibitz
C. N. Hickman	W. J. Shackelton
W. H. Holden	J. R. Townsend

In the Defense Communications Board, R. L. Jones is a member of the Committee on Aviation Communications. R. R. Williams directs vitamin studies for the National Research Council. Some sixty of the Laboratories' staff are employed in telephone problems which have been directly occasioned by the national defense situation, and another eighty are engaged in fundamental research for which the methods and point of view have been changed because of problems suggested by defense activities.

Fifty-four members of the Laboratories are now on active duty with the armed forces, and four men are temporarily transferred to the Navy Department for work on various technical projects.

New Equipment for New York-Philadelphia Coaxial

The Stevens Point-Minneapolis system, which is to go into commercial service on July 1, will include initially only sufficient equipment for handling a single supergroup of 60 channels. In order to obtain a more complete test of the coaxial terminal equipment, which is planned to handle a maximum of 480 channels, and in order to try out equipment for branching off groups of channels from the coaxial system at an intermediate point, equipment is now being installed for trial at New York, Princeton and Philadelphia. This equipment, which comprises four channel banks, two group banks, eight supergroups, and two blocking filters for branching tests, repre-

sents merely that fraction of the complete terminal and branching point equipment which is considered necessary to obtain adequate information. Nevertheless, it bulks quite large, no less than thirty bays in all.

Prior to installation on the New York-Philadelphia circuit, the new 480-channel terminal and branching point equipment had been tested in the Toll System Development Laboratory in the Graybar-Varick Building. The accompanying photographs show some of the testing work. Some idea of the magnitude and complexity of the development and testing work on the coaxial terminal and branching point equipment will be had from the fact that the equipment now under test, though only a part of the total ultimately required, includes six different designs of amplifiers, fourteen varieties of modulators, and a total of some sixty-five different designs of filters.

The Telephone Business

During the second year of the New York Telephone Company's weather forecast service, known to telephone subscribers as WEather 6-1212, the average number of daily calls was 19,000, compared to 16,000 for the first year. The volume of calls to the bureau varies with the weather. Sudden changes generally bring a flurry of them and interest is greater in summer than in winter. July 30, 1940, set the bureau record with 78,861 calls, the temperature having reached 94.3 degrees that day. The St. Valentine's Day storm on February 14, 1940, induced the largest total of cold-weather calls—57,688.

Since the opening of the bureau for New York City and vicinity on April 8, 1939, similar bureaus have been opened in Chicago, Detroit, Washington, Baltimore and Boston.

* * * * *

There was a gain of about 123,700 telephones in service in the principal telephone subsidiaries of the American Telephone and Telegraph Company included in the Bell System during the month of March. The gain for the previous month was 118,600 and for March, 1940, 82,800. The net gain for the first three months of this year totals 371,500 as against 260,200 for the same period in

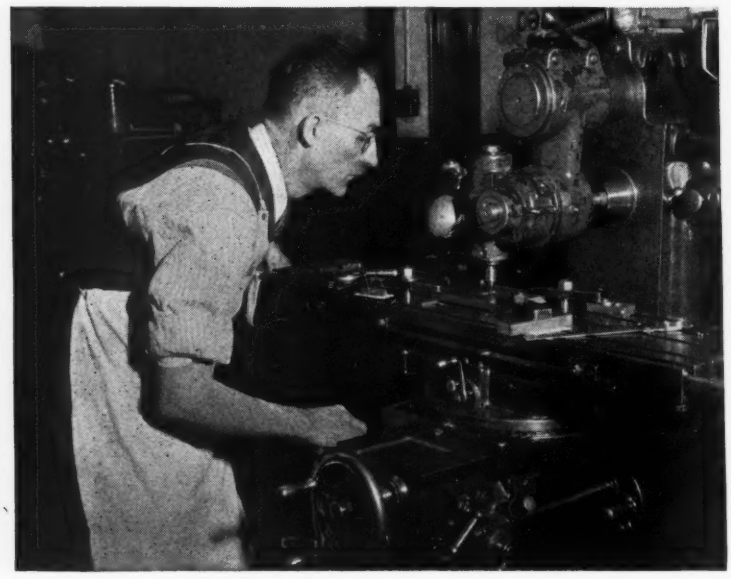
W. D. Mischler making adjustments on the four-kilocycle harmonic producer circuit used to provide carrier frequencies. This is part of the new terminal equipment for the New York-Philadelphia coaxial system

1940. At the end of March of this year there were, throughout the Bell System, approximately 17,854,800 telephones in use.

Colloquium

R. O. Grisdale, at the March 24 meeting of the Colloquium, spoke on *The Structure of Black Carbon and Its Bearing on Microphonic Contacts*. There are just two fundamental forms of carbon, diamond and graphite, and all varieties of black carbon are composed of graphite crystals. Despite this fact the properties of black carbon vary over very wide ranges and it is natural to seek the cause in the properties of the crystals, in their sizes, and in the manners in which they are packed together. In the pyrolytic carbon which covers the surfaces of roasted anthracite coal or which is deposited on insulating bases to provide synthetic microphonic materials and resistors suitable for high-frequency uses, the graphitic crystals are largely preferentially oriented with respect to the surface. It has been found that the extent of this preferential orientation depends on the conditions under which the carbon is produced, and that many of the properties of bulk pyrolytic carbon and of microphonic carbon contacts are directly related to the extent of this orientation. These correlations find a reasonable interpretation in terms of the measured anisotropic properties of single crystals of graphite. While many properties of black carbon and of carbon contacts are related to the fundamental structure of the material, this is not true of the microphonic sensitivity of contacts which, in conformity with the accepted elastic theory of microphonic action, depends primarily on the geometry of the contact surfaces.

Graduations on an aluminum apparatus panel being engraved by Edward White of the Development Shop



Rudolph Slovenz of the Precision Shop milling out a plate for a die that is used to mold part of a line relay

* * *

"Electron Inertia Effects," by F. B. Llewellyn, Circuit Research Engineer of the Laboratories, has recently been published by the Cambridge University Press as one of the Cambridge Physical Tracts. The book outlines the fundamental plans on which the operation of vacuum tubes depends at frequencies where the inertia of electrons plays an important part in the performance; it shows how to use

these principles by applying them to several types of tubes. Electron-inertia effects in older branches of physics are first discussed, and this leads on to modern vacuum tubes where electron-inertia becomes of increasing importance as the frequencies required are pushed up. The author particularly emphasizes applications in most general use, but in a final chapter deals with the latest applications and developments, and points the way to further research. Chapter subjects are:

The Significance of Electron-Inertia Effects
The Fundamental Equations
Direct-Current Relations
First-Order Solution
First-Order Relations in Diodes
First-Order Relations in Negative-Grid Triodes
Second-Order Effects
Other Electron-Inertia Effects

* * * * *

ANGUS HIBBARD, former vice president and general manager of the Chicago Telephone Company, has written a book of personal memoirs under the title "Hello—Goodbye. My Story of Telephone Pioneering." Described as "the autobiography of a joyous octogenarian," the book has been in preparation for about five years. The publisher's announcement states that the author, who was the first general superintendent of the A. T. & T. Company, is the only surviving member of the Headquarters group of the 1880's. The publisher is A. C. McClurg & Company, Chicago.

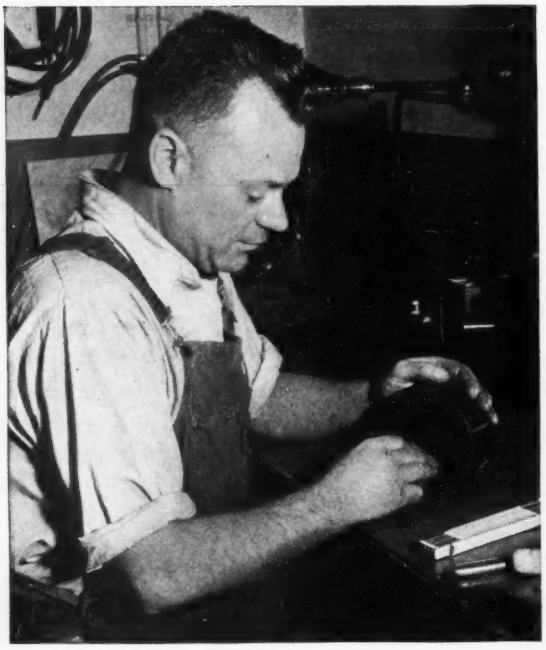
* * *

A POPULAR HISTORY of the telephone and of its effect on the daily lives of people throughout the world has been written by Marion May Dilts under the title "The Telephone in a Changing World," published by Longmans, Green and Company. Miss Dilts was formerly a member of the Quality Assurance Department of the Laboratories. The book is well illustrated and is written in a style that should appeal to the intelligent layman who wishes to make himself familiar with the story of the telephone without being burdened by technical details.

* * * * *

THE POLE-PIECES of the electromagnet shown in the photograph on page i are shaped to fit the relay structure and they have non-magnetic end plates of stainless steel to prevent the relays from sticking, when passed between the poles of the electromagnet. To adjust for relays of different dimensions, the pole-piece at the attendant's right is movable and can be quickly reclamped. The base plate and upright members which support the coils form the return magnetic circuit. This remagnetizer operates on 24 volts d-c and requires 3.5 to 4.5 amperes. The coil covers have been removed from the remagnetizer to show the general construction. The engineer shown in the photograph is G. G. SMITH of the Switching Apparatus Development Department.

Tommy O'Neill, tool-crib attendant of the Building Shop, withdraws rope tackle



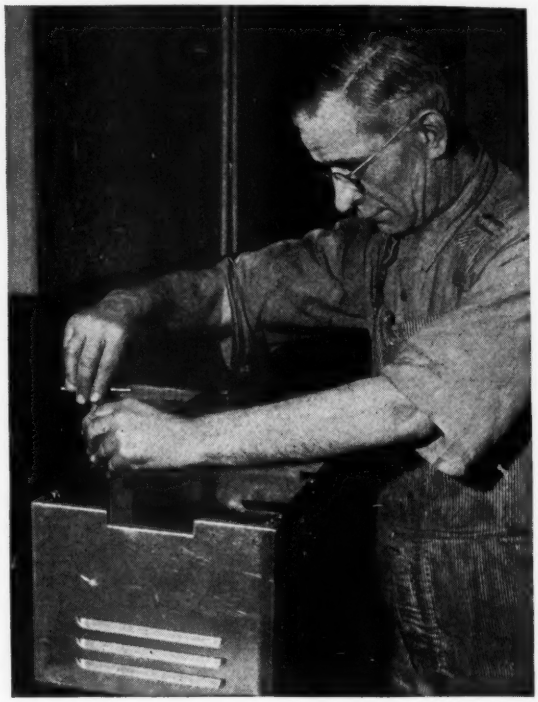
Frank Frohner cleaning the stator of an a-c motor in the Electrical Repair Shop

F. B. JEWETT attended the spring conference of Bell System Presidents, their initial session having been held on April 8 in New York City.

ON MARCH 28, DR. JEWETT, as President of the New York Museum of Science and Industry, took part in the preview broadcast for the Press Photographers' Exhibit at the Museum, welcoming those assembled.

O. E. BUCKLEY, A. TRADUP and F. J. SINGER attended Army Day ceremonies at Fort Monmouth on April 7, being part of a Bell System group who were the guests of Brigadier General Dawson Olmstead, commanding officer at this training base. In addition to the ceremonies, the group inspected the Signal Corps School, the Laboratory, and the Replacement Center.

ON APRIL 4, fifty-four senior electrical engineering students of Pennsylvania State College with Professors E. B. Stavely and A. H. Forbes made an inspection trip through part of the Laboratories. After being welcomed by E. W. WATERS the group inspected the Museum where the exhibits were described by W. C. F. FARNELL. On the trip through the building microphonic action studies were discussed and demonstrated by C. H. HAYNES; magnetic materials, D. M. CHAPIN; frequency standards, W. A. MARRISON; microscopic work, MISS A. K. MARSHALL; high-speed motion pictures, H. J. SMITH; timber investigations, A. H. HEARN; mechanical wear testing, W. A. KRUEGER; materials testing, I. V. WILLIAMS; and crossbar dial system, A. S. PAGE. Guides were P. V. DIMOCK, G. G. SMITH, C. L. KRUMREICH, C. C. HOUTZ,



A test-set case constructed of metal being tapped by George Gerry of the sheet metal group in the Development Shop

L. F. WILLEY and R. H. VAN HORN. Arrangements were handled by L. S. O'ROARK and G. F. FOWLER.

MEMBERS OF THE LABORATORIES who have been granted leaves of absence to enter military or naval services since the last issue of the RECORD are R. J. DROUT, Company E, 13th Infantry, Fort Jackson, Columbia, South Carolina; T. J. GILCHREST, Troop C, Fifth Training Squadron, Cavalry Replacement Center, Fort Riley, Kansas; F. J. HURT, Company B, 5th Signal Corps, Fort Monmouth, New Jersey; H. J. KEEFER, 5th Coast Artillery, Fort Hamilton, New York; R. A. KEMPF, Communication Security, Naval Communication Service, Navy

Department, Washington; R. T. MONAHAN, 96th School Squadron, Air Corps, Maxwell Field, Montgomery, Alabama; and K. J. OGAARD, Company A, 4th Medical Battalion, Fort Benning, Georgia.

HARVEY FLETCHER, at Los Angeles on April 8, spoke on *Hearing, the Determining Factor for High Fidelity* before a group of students at the University of California.

F. S. GOUCHER presented his lecture-demonstration *The Microphone and Research* before a combined meeting of the Rochester sections of the A.I.E.E. and I.R.E. and the Rochester Engineering Society, held on March 6.

A. R. SOFFEL left for Hollywood on March 21 to assist in making some special recordings to be used in a technical demonstration to be held before a meeting of the Society of Motion Picture Engineers and the Acoustical Society in Rochester on May 7.

R. R. WILLIAMS participated in the Science Forum Broadcast of the General Electric Company over stations WGEA and WGY. The subject of his talk was *Chemistry Behind the Telephone.*

AT THE ST. LOUIS meeting of the American Chemical Society the following papers were presented: *The Artificial Reinforcement of Processed Foods* by R. R. WILLIAMS; *Methods of Molecular Weight Determination for Linear Polymers* by W. O. BAKER, C. S. FULLER and J. H. HEISS, presented by Mr. Baker; and *Viscosity-Molecular Weight of Rubber* by A. R. KEMP and H. PETERS, presented by Mr. Kemp. C. C. HIPKINS attended meetings of the Paint and Varnish Division of the Society held during this meeting.

B. L. CLARKE has been reappointed for a one-year term to the Supervisory Committee of Standard Methods of Analysis of the American Chemical Society.

H. G. ARLT spoke on *Metal Finishes* before the Design Forum of the Laboratories. He discussed recent developments in finishes for metal telephone parts, including an exposition of the useful design characteristics of insulating enamels, oxidized aluminum

At the left Margaret Stonbridge is shown operating one of the five mimeograph machines which produce approximately 120,000 *copies a week while at the right Irene Walsh operates one of the two Ditto fluid machines which produce* 20,000 *copies a week*

finishes, coil-impregnating varnishes, heavy dipped finishes and bright zinc finishes.

C. C. HIPKINS discussed problems of finishes for equipment at the Point Breeze plant of the Western Electric Company. Mr. Hipkins has been appointed a member of the Advisory Committee to the Protective Coating Section, Division of Purchases of the Office of Production Management and, on March 29, attended the organization meeting of this committee in Washington.

H. G. ARLT, K. G. COMPTON and C. H. SAMPLE discussed testing of protective coatings at the National Bureau of Standards, Washington. Mr. Arlt has been appointed an advisor on corrosion by the Ordnance Department of the U. S. Army. In this capacity he attended a meeting of the Research Advisory Committee on Corrosion which was held at Rock Island Arsenal, Illinois.

R. L. SLOBOD visited Philadelphia in connection with the flexible brush trials on panel-bank equipment.

H. W. HERMANCE, at central offices in Philadelphia and Washington, studied ventilation and terminal maintenance procedures.

R. O. GRISDALE presented a paper *The Structure of Black Carbon and Its Bearing on Microphone Contacts* before a meeting of the American Physical Society held in New York City on March 28.

W. R. BENNETT was in Minneapolis and Eau Claire during the latter part of February and the early part of March making modulation tests on the Minneapolis-Stevens Point coaxial cable.

H. W. BODE discussed *Mathematics in Communication* on March 31 before the New York section of the A.I.E.E.

AN ARTICLE entitled *Measurements of Or-*

This truck carries an artificial lightning generator and a cathode-ray oscillograph used in lightning protection studies. E. D. Sunde is shown discharging the surge generator into one end of a buried cable at Forked River, New Jersey, where several types of small cable have been buried for observations with both natural and artificial lightning

Joseph Kocan of the Development Shop tapping a vacuum tube detail

chestral Pitch by O. J. Murphy was published in the January issue of *The Journal of the Acoustical Society of America.*

R. Bown, D. A. Quarles and P. Mertz attended the hearing on proposed television standards before the Federal Communications Commission in Washington during the latter part of March.

C. R. Burrows, on April 18, lectured on *Calculations of the Ground Wave in Radio Transmission* before the graduate seminar of the Polytechnic Institute of Brooklyn.

At the April 4 meeting of the Radio Colloquium held at the Deal radio laboratory, A. M. Skellett discussed *New Applications of Electron Beams.*

C. N. Anderson and A. B. Bailey were in Boston on March 20 and 21 to discuss with engineers of the New England Telephone and Telegraph Company preliminary plans for an emergency radio telephone system for motor cars.

C. A. Webber, at the Western Electric Company's Point Breeze plant on March 15 and 27, discussed cord development problems.

D. R. Brobst, W. J. Clarke and J. M. Finch visited Rhinelander, Wisconsin, and Akron, Ohio, on matters pertaining to development problems involved in the use of substitute materials in the manufacture of central-office cables.

Coil and transformer problems were discussed by W. Fondiller, W. J. Shackelton, F. J. Given, and E. L. Schwartz at the Kearny plant.

Bob Molloy of the pipe-fitting group in the Building Shop threading a two-inch pipe

N. Botsford visited the Naval Ordnance laboratory in Washington.

At the Hawthorne plant of the Western Electric Company H. A. Frederick, H. O. Siegmund, J. J. Kuhn and R. L. Lunsford discussed switching apparatus development projects; F. W. Treptow, wiring problems; T. J. Grieser, general problems relative to senders; T. C. Campbell, rolling ladders, ladder tracks and methods of installation; L. N. Hampton, central-office maintenance items; and G. G. Winspear, the testing of the initial factory production of a new jacketing material that is being employed for buried cable.

Miss H. E. Rex

A. M. Banscher

Albert Weller

Three members of the Laboratories have recently retired from active service—Miss Hedwig E. Rex on the sixth of April and A. M. Banscher and Albert Weller on the thirty-first of March.

Miss Rex joined the Western Electric Company in 1910 and after being a collator, file clerk, telephone dictation typist, mail clerk and messenger supervisor, she became a secretary in the Systems Development Department. In 1922 she joined the stenographic service group of this department and later became an estimator. She transferred to the Outside Plant Development Department in 1929 with secretarial duties and from 1932 until her retirement performed similar work in the Transmission Apparatus Development Department.

Mr. Banscher joined the Apparatus Design Department of the Western Electric Company in 1911 as a draftsman when there were only twelve draftsmen in the department. He worked on all kinds of telephone apparatus including jacks, signal equipment and telephone sets. In 1916 he joined the design group where he specialized on the design of mechanical locking keys. He was associated with the designing of the "shepherd's crook" spring used in keys. Since 1925 Mr. Banscher had been in the specifications group of the Transmission Apparatus Development Department where he first worked on specifications for radio apparatus, particularly that used in broadcasting equipments. More recently he had been checking specifications covering central-office, subscriber-station and outside plant apparatus.

Mr. Weller of the Switching Apparatus Development Department entered the employ of the Western Electric Company in 1906 as an electrician. In those days the electricians not only wired up the motors and performed similar jobs but in addition installed and cared for the telephone communicating system within the building, the annunciators and the like. He was engaged in this work until 1919 when he joined the Apparatus Development Department. Since that time he had assisted in the development of many types of apparatus through the construction of models and the building of special testing equipment. In this work he was particularly ingenious in translating new ideas into workable design.

* * * * *

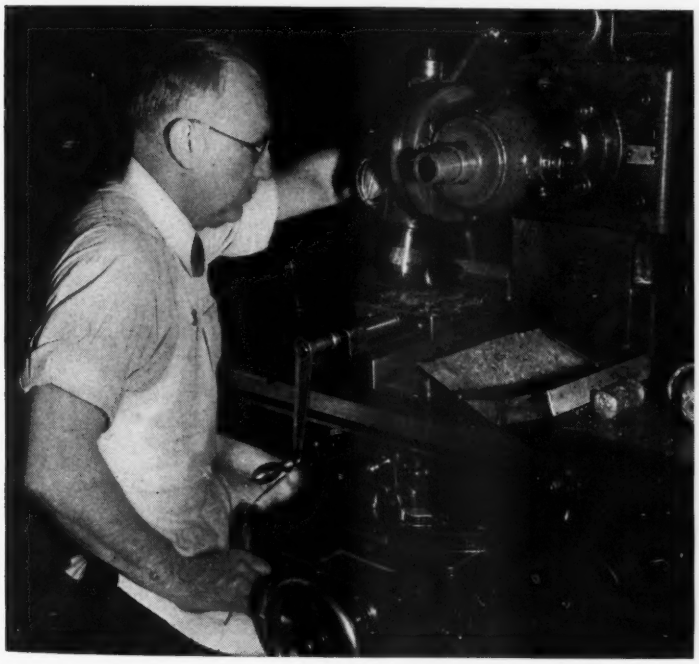
J. R. Townsend addressed the New Haven Chapter of the American Society for Metals at a meeting held in Bridgeport on *Fatigue and Its Relation to Mechanical and Metallurgical Properties of Metals*.

R. G. Watling and E. M. Patterson visited New Haven and Hartford to discuss maintenance in connection with specific switching apparatus items. Mr. Watling also visited Columbus, Dayton, and Springfield, Ohio, on similar matters.

At the spring meeting of the American

Society for Testing Materials, held in Washington from March 3 to 6, representatives at the various committees attending meetings included H. G. ARLT, paint, varnish, lacquer and related materials, corrosion of iron and steel, electro-deposited metallic coatings, and light metals and alloys, cast and wrought; J. A. ASHWORTH, magnetic materials; R. BURNS, W. A. EVANS and K. G. COUTLEE, electrical insulating materials and plastics; W. E. CAMPBELL, corrosion of non-ferrous metals; K. G. COMPTON, electro-deposited metallic coatings; B. L. CLARKE, methods of testing chemical analysis of metals; J. M. FINCH, electrical insulating materials; C. J. FROSCH, plastics; G. R. GOHN, copper and copper alloys; C. H. GREENALL, copper and copper alloys, and light metals and alloys; C. D. HOCKER and A. P. JAHN, corrosion of iron and steel; W. E. INGERSON, methods of testing, and indentation hardness; J. H. INGMANSON and F. S. MALM, rubber and rubber products; C. H. SAMPLE, corrosion of ferrous and non-ferrous metals, and electro-deposited metallic coatings; J. R. TOWNSEND, die-cast metals and alloys; J. H. WADDELL, symposium on color; and W. W. WERRING, impact testing.

Beulah Marion winding a solenoidal coil on one of the winding machines in the Development Shop



William Bodenstedt machining a grinding fixture guide on a milling machine in the Development Shop

W. J. TIETZ and M. W. LANE of Hawthorne visited the Laboratories to discuss step-by-step apparatus.

R. E. ALBERTS of the Outside Plant group at Point Breeze went to Kearny to discuss toll-cable engineering.

R. P. ASHBAUGH of the Outside Plant group at Kearny went to Point Breeze in connection with experimental work on protective coverings for lead-sheathed cable.

R. H. COLLEY attended the Executive Committee meeting of the American Wood-Preservers' Association held in Chicago on March 13.

J. G. SEGELKEN was in Pittsburgh where he attended a committee meeting of the

American Wood-Preservers' Association studying the behavior of paint coats on creosoted wood.

DURING THE MONTH of April the following members of the Laboratories completed twenty years of service:

Research Department

W. A. Marrison — Miss Isabel V. Wenzel

Apparatus Development Department

D. H. Gleason — F. H. Hewitt

Systems Development Department

E. L. Baulch — E. W. Olcott
H. D. Kelso — M. O. Schrum
C. D. Koechling — C. A. Smith
W. I. McCullagh — T. A. Spencer

General Service — *Plant Operation*

J. H. Connerty — Vincent Montagna

TWENTY-FIVE YEAR SERVICE ANNIVERSARIES

AMONG THE BELL SYSTEM MEN who were in the A.E.F. in 1918 were two who had entered Western Electric's Engineering Department on the same day in 1916 and who received 25-year buttons last month. One is ROBERT O. BURNS, JR., who after two years of drafting and loading-coil design went overseas with the Sound and Flash Ranging Section of the U. S. Engineers. From front-line service at St. Mihiel he returned to his former work. Some years later he went to a group which installed the then-new public address systems. With that group he went to E.R.P.I. in 1928 where he became the head of a survey analysis group which prepared specifications for sound-picture equipments. Among pleasant memories are the designs he made for private theatre installations on several large country estates, and the contacts with architects and owners. Returning to the Laboratories in 1937 he first worked on repaired-apparatus engineering and last year transferred to laboratory studies of lamps.

Mr. Burns lives in Ridgewood, New Jersey, where he is a leader in men's activities in his church. His particular pride is the artistic ability of his two sons who are interested in architecture and painting.

* * * * *

THE OTHER WORLD WAR veteran is ARTHUR W. DRING, now of the Cable Apparatus group, who was a Sergeant in the Signal Corps Research and Inspection Division with headquarters in Paris. Previously a draftsman, on his return he took up specification work. When Western Electric took up the manufacture of step-by-step apparatus, Mr. Dring was at the head of a group which helped to convert A. E. Co. specifications and drawings to Western Electric standards. In 1927 he transferred to cable terminal design. More recently he has been working on terminals for coaxial cables.

One of the original five-man team, which has grown into the Bowling League, Mr. Dring keeps on rolling 175. One of his four children — M. W. Dring — is an equipment draftsman in the Davis Building. His home in Summit and a camp at Lake Owassa occupy his leisure time.

* * *

AFTER TRAINING at Pratt Institute and experience in mechanical design, HARRY A. REYBERT entered the Engineering Department of the Western Electric Com-

R. O. BURNS, JR.

A. W. DRING

H. A. Reybert

F. E. Engelke

pany in 1916 as a draftsman. Soon after, he was called into active service in the Mexican Border campaign and later trained for World War service. A substantial contribution to the war effort was his work on the first two-way radio set for airplanes and on apparatus for submarine detection. During the years which followed Mr. Reybert has worked on designs for hundreds of pieces of apparatus; his latest assignment is to new kinds of switching structures. A lifelong resident of Brooklyn, he now lives in the Fort Hamilton section of that city. He is a member of the Western Electric Post of the American Legion.

* * * * *

A youthful interest in electricity led Fred E. Engelke to join the Western Electric Company in 1916. Finishing his high school course during the evenings, he later supplemented it by courses at Brooklyn Polytechnic and in the Laboratories' Out-of-Hours Series. He is now a member of the station instruments group, which he joined soon after entering. A long-term activity was the development of equipment and methods for testing transmitters and receivers; present machines embody a number of his contributions. Some time ago he transferred to the receiver design group and is now engaged in the development of the new small vacuum-tube audiphone. Mr. Engelke lives in Woodhaven, Queens, with his wife and six-year-old son.

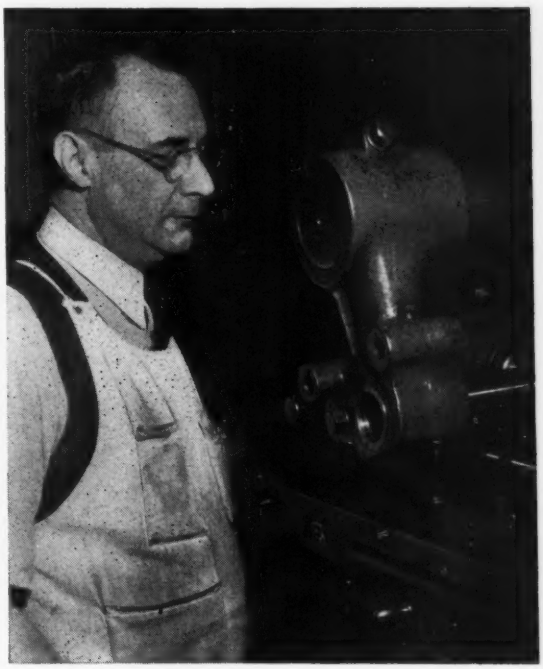
Repair work on linotypes and bookbinding machines before joining the Laboratories was Charles Haug's introduction to the machinist's art which he has been performing in the Development Shop for twenty-five years. By preference he operates the milling machine shown below. His service spans the transition from carbon-steel to high-speed alloy steels and from overhead belt drives to individual motors. Mr. Haug is married and lives in Ridgewood, Queens.

* * *

K. E. Hammer demonstrated the artificial larynx, the orthotechnic audiphone and the orthotronic audiphone to a group at the Hillside Presbyterian Church, Orange, New Jersey, on March 16.

H. F. Dodge is chairman of a committee of the American Standards Association which is working on the application of statistical methods to quality control.

E. C. Molina, on April 2, spoke on



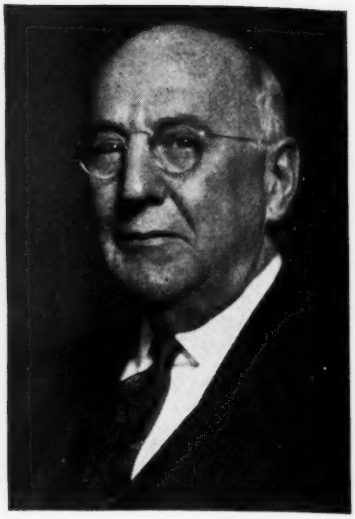
Charles Haug

A. W. LAWRENCE

of the Transmission Apparatus Development Department completed thirty-five years of service on April 16

THOMAS CREAVEN

of the Plant Department completed thirty-five years of service in the Bell System on the twenty-ninth of April



A. E. PETRIE

of the Equipment Development Department completed thirty years of service in the Bell System on April 10

Mathematics in the Telephone Industry before a joint meeting of the Mathematics and Science Clubs of the New Jersey State Teachers College that was held in Montclair.

H. E. MARTING was in Washington and T. C. CAMPBELL in Bethlehem on matters pertaining to rolling ladders, ladder tracks and methods for their installation.

J. T. MOTTER, together with engineers of the Western Electric Company, inspected step-by-step equipment at Bethlehem, Pennsylvania.

J. W. WOODARD, at Atlanta, discussed central-office problems with representatives of the Western Electric Company and engineers of the Southern Bell Telephone and Telegraph Company.

C. S. KNOWLTON was in Cleveland in connection with the power supply for the Republic Steel Company's teletype equipment.

H. M. SPICER discussed power relays with various manufacturers at Boston.

C. W. VAN DUYNE, with J. E. Palmer of the Installation Department of the

Henry Roeser, in the Precision Room of the Development Shop, grinding a hardened roll used on a mill in the Metallurgical Laboratory to roll wire into tape

Western Electric Company, observed production processes at the New Departure's bearing factory in Meriden, Connecticut.

F. T. FORSTER observed battery tests at Philadelphia.

W. A. MACMASTER and A. B. BAILEY, on a recent trip to Washington, discussed with engineers of The Chesapeake and Potomac Telephone Company proposed new radio equipment.

E. W. HANCOCK spent most of the month of March in Chicago, and several days at Baltimore and Pittsburgh, in connection with the installation of crossbar offices.

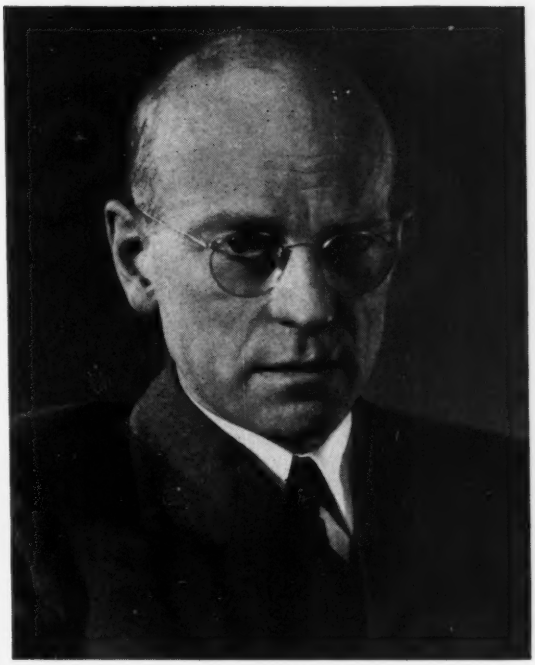
Eugene Flannery turning a steel shaft on an engine lathe in the Development Shop

G. A. HURST and W. I. MCCULLAGH spent two weeks at the crossbar installation at Dormont, Pennsylvania.

C. R. GRAY was in Syracuse for several days to study double connections on selectors in step-by-step offices.

P. W. SPENCE visited Bowling Green, Virginia, to investigate a contact between a power circuit and a telephone circuit.

MR. SPENCE also participated in an inspection of a water-pipe grounding situation



JOHN MILLS

Director of Publication completed thirty years of Bell System service on April 1

in Westtown, Pennsylvania, made in collaboration with the American Research Committee on Grounding.

D. E. BRENNEMAN investigated a contact at a crossing of power and telephone lines near Bath, Pennsylvania.

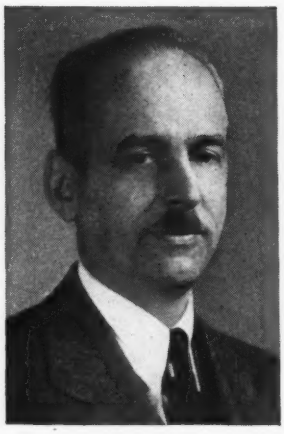
J. MALLETT and J. L. LINDNER were in Princeton on a field trial of the improved static-measuring equipment to be used in noise tests on several small type-K cables.

IN THE JOURNAL SQUARE central office of the New Jersey Bell Telephone Company, M. ARUCK and R. M. HAWEKOTTE made wave-shape tests on the 120-volt power circuit supplying fluorescent lamp units with shunt capacitors for power-factor correction.

The PAPER *Engineering Requirements for Program Transmission Circuits* by R. G. MCCURDY of the Laboratories and F. A. Cowan and I. E. Lattimer of the A. T. and T., presented at the A.I.E.E. winter convention, was published in the April issue of *Electrical Engineering*.

J. F. WENTZ and C. L. WEIS conferred in Boston with members of the staff of the Massachusetts Institute of Technology on special transmission problems.

Instructors of Five Out-of-Hour Courses, 1940-1941



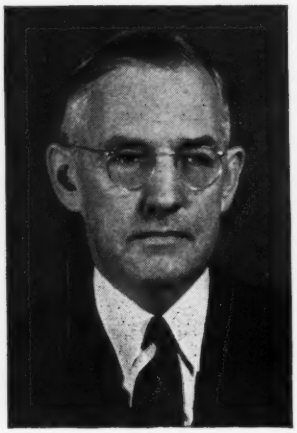
H. E. Haring
Applied Electrochemistry

C. H. Townes
Metal Physics

F. C. Nix
Metal Physics

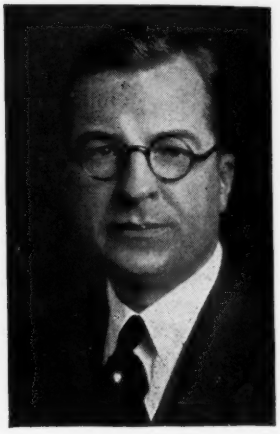
J. W. Dehn
Telephone Switching Systems

W. C. Somers
Standard First Aid Course of American Red Cross



L. C. Westcoat
Standard First Aid Course of American Red Cross

R. Pope
Standard First Aid Course of American Red Cross



W. S. Gorton
Mechanical Vibrations

W. F. Smith, Jr.
Standard First Aid Course of American Red Cross

C. N. Anderson
Standard First Aid Course of American Red Cross

C. Erwin Nelson
Standard First Aid Course of American Red Cross

L. E. Coon
Standard First Aid Course of American Red Cross

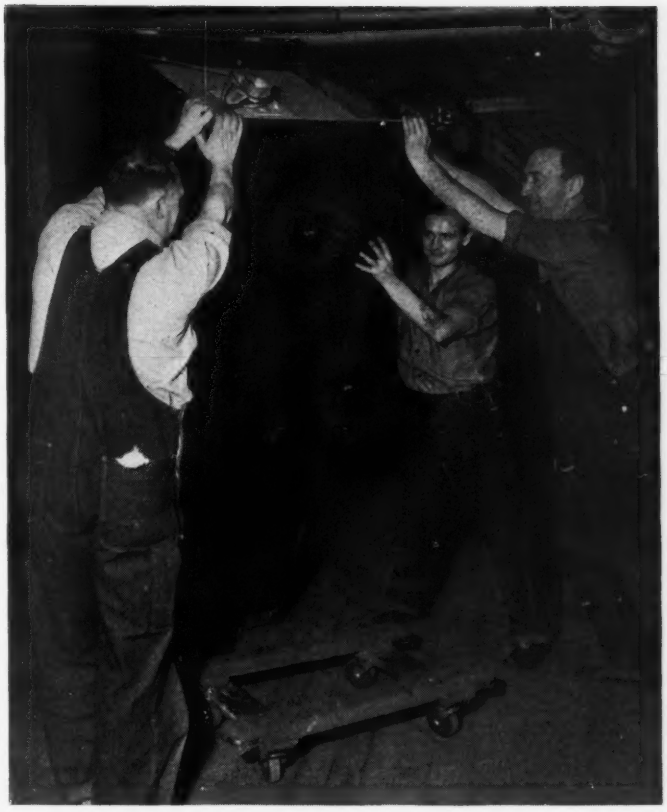
D. M. TERRY has been taking part in the field trial, on the Denver-Lamar line, of a modified pilot-channel control on a type-J carrier system for regulation under condition of sleet or ice on the open-wire lines.

H. B. BREHM and Q. E. GREENWOOD visited Holmdel and Manahawkin on cable investigations.

B. DYSART, who has been in Minneapolis in connection with the coaxial-cable installation between that city and Stevens Point, Wisconsin, discussed telephone and television phases of this system before a luncheon meeting of The Engineers' Club of Minneapolis on March 14. He repeated this talk before the Minneapolis Radio Club on April 10.

DURING MARCH, G. T. MORRIS, W. M. HILL and W. F. SIMPSON were at the Patent Office in Washington relative to patent matters.

IN PREPARATION for the Twelfth Annual Safety Convention of the Greater New York Safety Council, L. E. COON attended a meeting of the Arrangements Committee.



Harold Skou, Ralph Apetz and Jim Marshall, millwrights in the Building Shop, moving a telephone booth

M. S. MASON, on February 19, 20 and 21 with other Bell System representatives, visited the University of Illinois on college recruiting.

DURING THE FIRST QUARTER of 1941, the following members of the Laboratories have been enrolled as members of the Telephone Pioneers of America:

Bardsley, J. R.	Heitsmith, W. J.
Benedict, Miss I. H.	Honaman, R. K.
Bischoff, W. A.	Hopkins, H. F.
Bown, R.	Huber, G. H.
Brand, S.	Kiernan, Miss A. A.
Clarke, B. A.	Kuebler, R. E.
Crawford, A. I.	Lang, W. Y.
Deelwater, C.	Lunsford, R. L.
De Monte, R. W.	McDermott, Mrs. A.
Ferrigni, J. P.	Parsons, A. J.
Fetyko, S. J.	Popino, J.
Fetzer, K. M.	Smalley, M. N.
French, N. R.	Smith, D. C.
Friis, H. T.	Stevens, Miss E.
Gray, F.	Strachan, Miss J.
Wingardner, C. A.	

J. W. SCHMIED appeared before the Court of Customs and Patent Appeals in Washington relative to an application for patent.

THE LABORATORIES were represented in interference proceedings at the Patent Office by B. H. JACKSON before the Primary Examiner.

R. A. DELLER attended the meeting of the National Industrial Conference Board, held in New York City on March 27.

DURING THE month of February R. A. DELLER, with other Bell System representatives, visited a number of colleges throughout the Middle West, on college recruiting. On February 11 he visited The Ohio Bell Telephone Company offices in Columbus, and on February 25 the Chief Engineer's office of the Michigan Bell Telephone Company at Detroit where he discussed several other matters.

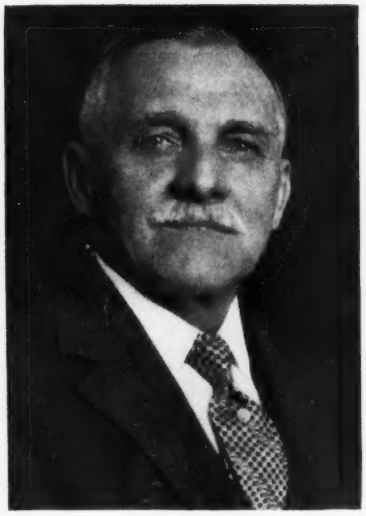
E. W. WATERS visited Cornell University on February 17, 18 and 19 with other members of the Bell System, to discuss employment with college students.

CONRAD SCHAUL, who retired from the Laboratories in 1929 after thirty-six years of active service, died on April 5. Mr. Schaul was a former instrument maker in the Development Shop.

* * *

JOHN MILLS visited Rochester to confer with the local committee on arrangements for a demonstration of stereophonic music during the forthcoming convention of the Acoustical Society and S.M.P.E.

T. M. ODARENKO visited the Point Breeze Works of the Western Electric Company in connection with the factory measurements on the Baltimore-Washington cable. Field measurements on this cable were made during the past month by G. B. ENGELHARDT and A. F. POMEROY.



CONRAD SCHAUL, 1857-1941

These included tests on a new type of coaxial cable laid on part of this route.

P. B. FINDLEY and R. L. SHEPHERD attended a conference of editors held under the auspices of the House Magazine Institute.

D. S. BARLOW and R. S. HAWKINS were in Philadelphia working on the special circuit which has been set up for the Philco Corporation.

H. A. ETHERIDGE participated in tests at Princeton of new cableman's test sets for use along K-cable routes.

C. L. WEIS and L. W. MORRISON went to Minneapolis to arrange for television tests on the Stevens Point-Minneapolis cable which R. J. SHANK, J. R. BRADY and J. J. JANSEN will conduct. J. P. RADCLIFF visited Minneapolis in connection with these tests.

DURING THE MONTHS OF JANUARY, FEBRUARY, AND MARCH, PATENTS WERE ISSUED TO THE FOLLOWING MEMBERS OF THE LABORATORIES

J. F. Barry
A. C. Beck
B. C. Bellows
B. G. Bjornson (3)
R. B. Blackman
F. E. Blount
J. H. Bollman
L. G. Bostwick
A. E. Bowen
R. B. Buchanan
H. T. Budenbom (2)
W. W. Carpenter
S. C. Cawthon
J. G. Chaffee (2)
R. W. Chesnut
R. E. Collis
G. W. Cowley
J. W. Dehn (2)
W. A. Depp
T. L. Dimond
J. T. Dixon
O. C. Eliason
C. B. H. Feldman
H. Fletcher
H. T. Friis
E. W. Gent (2)
F. Gray (2)
A. F. Grenell
K. E. Hammer
J. J. Harley
W. R. Harry
W. S. Hayford
R. E. Hersey (2)
W. H. C. Higgins
S. C. Hight
W. H. T. Holden
F. A. Hoyt
W. F. Kannenberg
R. J. Kent
A. P. King
G. V. King
R. E. King
B. J. Kinsburg
J. P. Kinzer
C. D. Koechling
J. G. Kreer, Jr.
E. Lakatos
R. F. Lane
W. V. K. Large
S. A. Levin
M. A. Logan
C. A. Lovell
C. W. Lucek
A. A. Lundstrom
J. B. Maggio
C. O. Mallinckrodt
W. A. Marrison
R. N. Marshall
W. P. Mason
E. C. Matthews
E. M. Matthews
T. A. McCann
J. B. McKim
S. T. Meyers
O. R. Miller
V. F. Miller
D. Mitchell
N. Monk
L. A. Morrison (2)
E. E. Mott (2)
A. H. Muller
O. Myers (2)
J. B. Newsom
R. S. Ohl
D. B. Penick
E. Peterson
R. E. Polk
H. M. Pruden (2)
J. E. Ranges
W. T. Rea
R. E. Ressler
G. A. Ritchie
D. D. Robertson
E. St. John
S. A. Schelkunoff
A. K. Schenck
O. A. Shann
T. Shaw
F. J. Singer (2)
W. Shockley
A. M. Skellett
A. K. Smith
G. C. Southworth
A. L. Stillwell
G. K. Teal
C. C. Towne
D. E. Trucksess
E. K. Van Tassel
E. F. Watson (3)
P. V. Welch
C. White
I. G. Wilson (2)
R. O. Wise
D. E. Wooldridge (2)
L. R. Wrathall

Measurement of Dynamic Characteristics of Vacuum Tubes

By J. B. MAGGIO
Transmission Development Department

IN THE design of broadband carrier telephone systems, the vacuum tube is one of the basic elements. Its most efficient operation as an amplifier requires that the proper voltages be applied to the electrodes and that a suitable load impedance be chosen. Unfortunately, one set of operating conditions will not result in optimum performance for all applications of a given tube. In general, the conditions for optimum performance in any particular case will depend upon the frequency band to be amplified, and the required gain, power output, and modulation performance necessary.

Instead of measuring the performance of the tube under several conditions in an actual circuit, however, one may determine its properties as an amplifier with a resistance load from a curve correlating instantaneous plate currents and control grid voltages. Such a curve is known as the dynamic transfer characteristic. It is unique for a given tube and specified operating voltages and load resistance. From this characteristic, the power output for any driving voltage, as well as the voltage developed across the load impedance, may be determined, and by applying special analyses, the relative magnitudes of the fundamental and harmonic components of the resulting plate-current wave may be computed. The dynamic characteristic is usually obtained graphically from a set of static characteristics for the tube. To provide a simpler and more rapid method, and one more free from the inherent errors of the graphical method, a circuit has been developed by the Laboratories that directly and accurately determines the dynamic characteristic.

A family of curves expressing the relationship between plate voltage and current for various grid biases comprises the static characteristics of a tube. Each curve represents the behavior of the tube with all factors constant except for arbitrary changes in plate voltage and the corresponding changes in plate current. For simplicity, they are taken with a battery connected to the plate, which gives

essentially a zero plate impedance. Such a set of curves for a pentode is shown at the left of Figure 1. Under operating conditions, however, while the applied voltages are fixed, there is a load resistance in the plate circuit, and the grid voltage is moved up and down from the biasing voltage by the applied signal. Under these conditions the relationship between instantaneous plate voltage and current would be represented by the diagonal line AB. As the grid voltage was increased by the signal, the plate current would increase, and this increased current through the load resistance would subtract from the applied plate potential to give a lower actual plate voltage. The tangent of the angle by which AB deviates from the vertical is equal to the load resistance. This is readily apparent because the tangent of the angle of deviation is PN ÷ NQ; PN is the decrease in plate voltage, which is $\Delta I_p R$—the product of the increase in plate current by the load resistance—and NQ is the increase in plate current, or ΔI_p.

With a line such as AB across the set of static characteristics, the dynamic characteristics may be plotted by projecting horizontally each intersection to determine the points on a curve representing the relationship between plate current and grid voltage for that particular load resistance. Such a curve is indicated at the right of Figure 1. A scale of instantaneous grid voltages is laid out along the abscissa, and the intersection of AB with each curve at the left is projected over and forms a point of the dynamic characteristic where it crosses the vertical from the corresponding grid voltage on the abscissa scale.

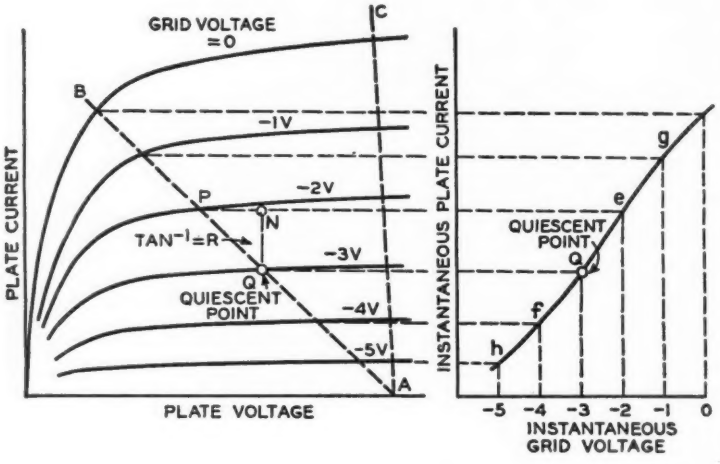


Fig. 1—Typical static characteristics of a vacuum tube at the left, and the dynamic transfer characteristic derived from them at the right

Not only is this graphical method of determining the dynamic transfer characteristic rather slow, but in addition it has several other disadvantages that are more or less inherent. The static curves are normally obtained by applying d-c voltages, and the plate current is also d-c. A dynamic curve, however, is used to determine the behavior of a tube under operating conditions when an a-c potential is applied to the grid, and when the plate current and voltages are also a-c, or rather a-c superimposed on d-c. The heating of the elements for these two conditions is different, and thus a characteristic determined with direct current will not be strictly correct for alternating current. Moreover there is always some inaccuracy with a graphical method because of uncertainty as to the exact points of the intersections of the lines, particularly when they intersect at a small angle.

In the method recently developed, these disadvantages are overcome by making direct measurements on the tube under a-c conditions. A dynamic transfer curve may thus be obtained rapidly and under the heating conditions that hold when the tube is in normal use. A simplified schematic of the circuit employed is shown in Figure 2. In brief the method consists in applying the desired d-c plate and grid biasing potentials, and then superposing on the grid bias a pure sinusoidal driving voltage of carefully determined value, and measuring the corresponding plate current. The method can be indicated by reference to Figure 1. Any set of plate and grid voltages determines a quiescent point such as Q. For any applied alternating driving potential, the grid voltage is driven alternately above and below the grid voltage of the quiescent point, and the plate current will alternately increase and decrease. The plate current has an a-c and a d-c component, the latter is determined separately, and the maximum positive and negative peaks of the a-c component are added to and subtracted from it to give the plotted points of the dynamic characteristic.

The driving circuit consists of a tapped potentiometer made up of equal resistance steps, one of which is the heater of a thermocouple. An oscillator applies a pure sinusoidal voltage to the potentiometer, and its output is adjusted until the galvanometer connected to the thermocouple indicates that 1-volt peak is applied across the thermocouple. Under these conditions, the steps of the potentiometer apply to the grid multiples of 1 volt peak from the bias voltage. Errors that might be caused by grid current of the tube under test are made negligible by small resistances in the potentiometer.

The alternating and direct components of the plate current are separated by a parallel circuit. One branch consists of the large inductance L, and the other of an adjustable resistance R_L, a smaller resistance G_V, and a large blocking condenser, which prevents the passage of direct current through this branch. At the test frequency used, the impedance of L is so large compared to that of the other branch, that only direct current passes through it. Thus the d-c component flows only through L, and is measured on a milliammeter, while the a-c component flows only through the R_L branch, and is measured by adjusting G_V until the peak voltage across it is just one volt, which is determined by comparison with the voltage across the thermocouple in the grid circuit. The set thus measures the behavior of the tube in a circuit where the impedance

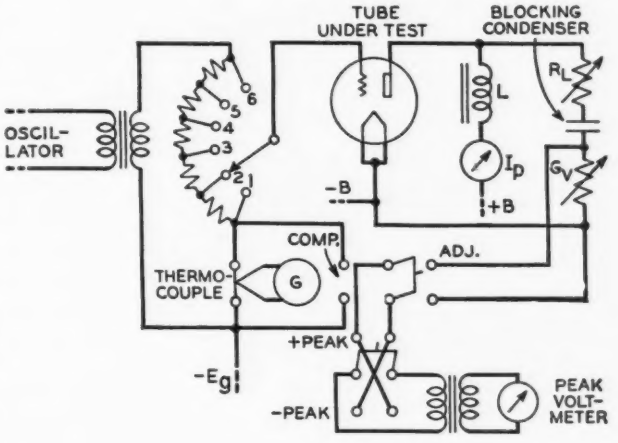


Fig. 2—Simplified schematic of the new circuit developed for measuring the dynamic characteristics directly

presented to the plate is low to direct current, and a pure resistance at frequencies in the working band. Such conditions are normally fulfilled in a transformer-coupled output stage, such as is used in most broad-band carrier amplifiers. The behavior of the tubes in resistance-coupled amplifiers may be readily determined by suitable interpolation.

The voltage across G_V is made equal to that across the thermocouple by adjusting G_V until the indication of a peak voltmeter is the same when it is connected across G_V as when connected across the thermocouple. A double-pole double-throw switch permits the meter to be thrown rapidly from one to the other, and a similar switch is connected so that either the positive or negative peaks may be read.

Since the voltage across G_V is the IR drop through it, the current through it is equal to the reciprocal of the resistance when the voltage drop is unity. Thus by using a conductance standard for G_V, the current in milliamperes is equal to the conductance in millimhos. Actually, the scale of the conductance standard is marked in milliamperes in order to make it direct reading.

The current measured on the milliammeter is the d-c component of the plate current for the plate potential and grid biases applied. With the grid potentiometer set at the 1-volt step, and assuming the conditions of Figure 1, the positive peak of a-c plate current added to the d-c component would give the point *e* of the right-hand diagram of Figure 1, and the negative peak subtracted from the d-c component would give the point *f*. A separate adjustment of G_V is required, of course, for positive and negative peaks. Similar readings with the potentiometer on step 2 would determine points *g* and *h*, and so on for other points. Asymetric distortion of the dynamic transfer characteristic results in a change of d-c plate current when the signal is applied. When this occurs, the d-c bias is adjusted to compensate for change. Characteristics corresponding to Class B and Class C operation may be taken in this way.

This new circuit readily adapts itself to other measurements than that of the dynamic characteristics. A set of static characteristics, for example, may be obtained under heating conditions more nearly those encountered in normal operation than are curves determined with d-c potentials alone. By reducing R_L of Figure 2 to zero, the load impedance is only G_V, across which there is never more than one volt because of the measuring procedure. Such a low-resistance load would be represented on Figure 1 by an almost vertical line such as AC. Then by using a grid-biasing voltage nearly that required to extinguish the tube, and reading only the positive peaks, points on the static curves are obtained for each setting of the potentiometer. Under these conditions, both the plate and screen currents are cut off during nearly all of the negative half-cycle, or approximately half of the time, and much of the heating present with the more usual method is avoided. At each reading, a correction of 1 volt is made to compensate for the drop across G_V, so that the points plotted lie in a vertical line one volt below A. By taking a series of such readings at various plate potentials, the static characteristics are obtained.

The circuit may be used for measuring the transconductance from control grid to plate, which is equal to the ratio of change in plate current to a

small change in grid bias at constant plate potential. As the load resistance is made small compared to the internal resistance of the tube, the voltage ratio from grid to plate approaches the product of transconductance and load resistance. By making R_L equal to zero, setting the grid potentiometer to the 1-volt tap, and adjusting G_V until there is one volt across it, the voltage gain through the tube, or the ratio of plate to grid voltage, is unity, and the transconductance will be equal to one divided by the load resistance, which is G_V. Since the reciprocal of G_V is the conductance, which is read directly from the G_V dial, the transconductance is obtained directly. When the voltage gain has been adjusted to unity with the grid potentiometer on the 1-volt tap, the calibration of G_V is independent of the actual grid voltages. Consequently, when measuring small tubes in which a grid swing of one volt peak can not be considered small, the oscillator output is reduced so that only a small fraction of a volt is applied to the grid of the tube.

The circuit as used in the carrier repeater laboratory is shown in the photograph at the head of this article. Four, five, six, seven, and eight-prong sockets have been provided together with jacks and plugs so that tubes with various basing arrangements may be accommodated. Plate and screen voltages are secured from regulated power supply units, and are continuously variable. Heater and grid voltages are also adjustable from the control panel, thus enabling any desired set of operating voltages to be quickly set up. Measurements of dynamic transfer characteristics obtained with the circuit have been particularly useful in the determination of optimum operating conditions for tubes in broad-band amplifiers.

A. B. Clark Honored by University of Michigan

A Citation as Distinguished Alumnus has been awarded to "Alva Benson Clark, member of the Class of 1911 of the College of Engineering, University of Michigan, now Director of System Development in the Bell Telephone Laboratories, who since his graduation has devoted his own inventive skill and his ability to direct research to the expansion, improvement, and cost reduction of telephone transmission, foreseeing the possibilities and anticipating the trend of the arts of communication; from his efforts have resulted many of the accomplishments of modern long-distance and multi-channel telephony."

Circuit-Riding the Coaxial Cable

By G. B. ENGELHARDT
High-Frequency Transmission

IN THE course of their development work, the Laboratories make many transmission tests in the field, far away from the usual laboratory facilities. The necessary equipment must be carried to the point of measurement and set up each day for the tests to be made. These open-air tests, besides the delays inherent in a daily setting up and dismantling, are always subject to interruption—sometimes sudden and unexpected—by bad weather, and to avoid such minor catastrophes, the apparatus has sometimes been arranged in trucks.

With the very wide band of frequencies of the coaxial-cable carrier system, it was evident that the amount of testing would be much greater than usual. The cold weather and snow prevalent over the route between Stevens Point and Minneapolis where the first commercial cable was being installed emphasized the need for protection for the apparatus and engineers. As a result, the two-door sedan shown above was converted into a mobile laboratory that could be used in all weather and in almost all places. Although mobile laboratories are not unusual, this test car is a particularly good example of compactness. It accommodates two engineers and over half a ton of equipment.

The equipment varies with the particular tests, but certain facilities

should always be available. In the design, therefore, certain equipment was permanently installed, and ample space was left for special apparatus for any one trip. Practically the entire inside of the car was rebuilt. The rear seat and most of the upholstery were removed and the double front seat was replaced by two individual, removable seats, which could be turned around to face the rear of the car while tests were being made. In place of the rear seat was the main test bench as shown in Figure 1. It is made in three sections: a low shelf directly above a spare tire compartment, a main bench above it, and a front hinged section, which may be turned back when not in use. The rear half of the lower shelf is occupied by the battery compartment, and a flush door in the upper bench surface gives access to it for maintenance. Figures 2 and 3 show the arrangement with certain testing apparatus in place.

At the left of the lower shelf, evident in Figure 3, is a power panel for controlling the various power supplies, and at the left of the spare tire are drawers for tools and other equipment. A rack for a soldering iron is fastened to one side of the car, where there are also compartments for thermometers, slide rules, small meters and writing materials. At the right of the lower shelf is a magneto telephone and compartments for leads and patch cords of various lengths. Lighting fixtures placed above the windows on both sides provide ample light under all conditions.

The main battery, in a ventilated compartment at the rear of the lower shelf, is rated at 100 ampere hours at 32 volts, and provides ample supply for an ordinary day's testing without operating any charging equipment. A rotary convertor, operated from the battery, provides a 110-volt, 60-cycle supply. This convertor is mounted under the hood just behind the radiator on the right-hand side as shown in Figure 4. On the other side, Figure 5, is a small gas-engine-driven generator used for charging the battery. In addition there is a 32-volt tungar rectifier that may be used for battery charging when the car is garaged where commercial power supply is available for this purpose.

As part of the permanent equipment, a high-gain detector, which may be connected to the car antenna for radio reception, is installed beneath the dashboard with all controls brought out in the dashboard itself, as shown

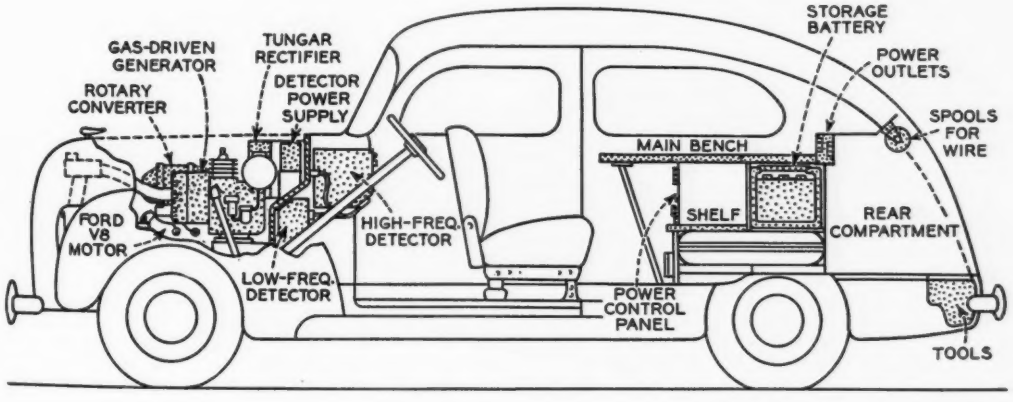


Figure 1

Figure 2

in Figure 6. This equipment covers the frequency range from 10 to 18,000 kc, and serves a variety of purposes. In connection with field measurements of transmission line characteristics, it sometimes eliminates the need for a separate high frequency detector, thereby saving considerable space. It is also useful for picking up the Bureau of Standards standard frequency broadcasts, and in conjunction with a built-in 100 kc crystal oscillator provides the car with a secondary frequency standard that is of high precision.

The rear luggage compartment of the car, Figure 7, is equipped with drawers for spare parts, a wire rack for reels of various sizes and types of wire, and a large tool compartment

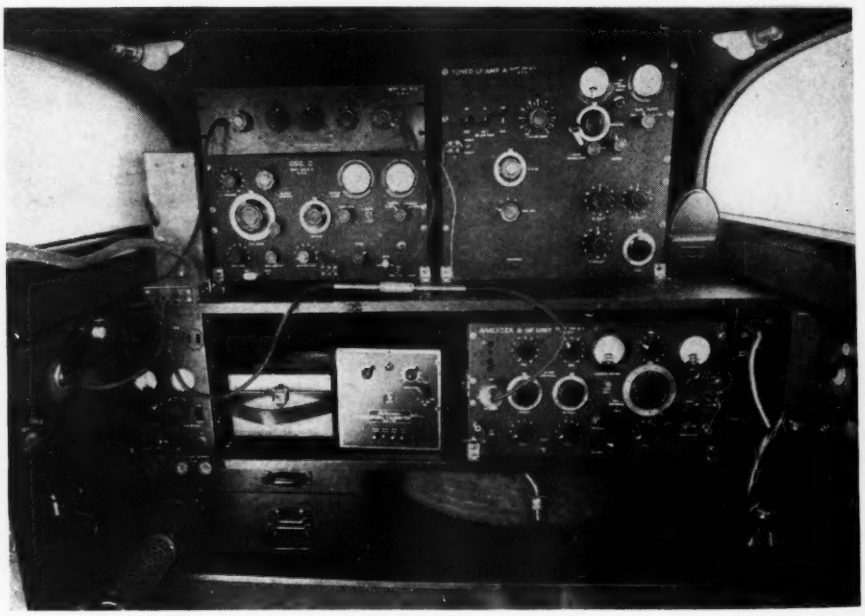


Figure 3

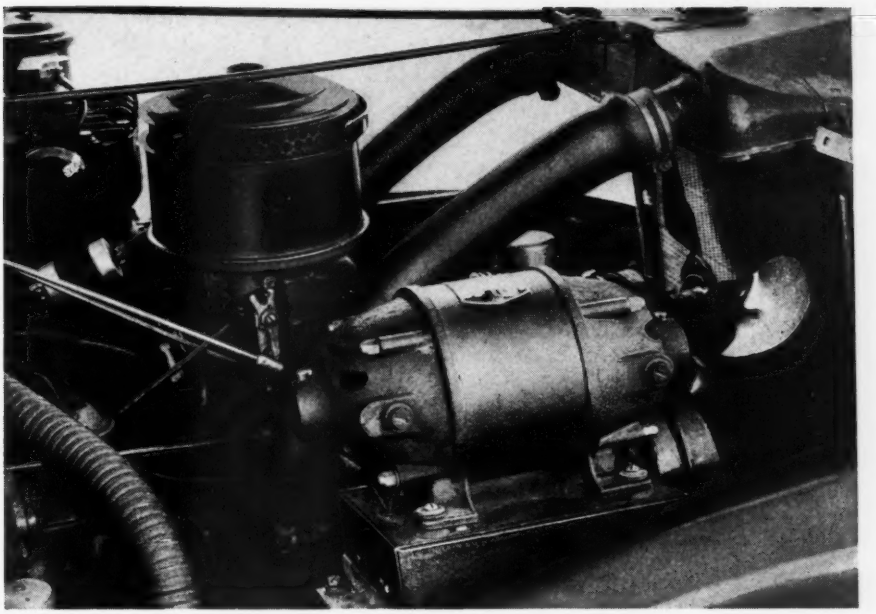


Figure 4

beneath the floor. The major part of this space, however, is available for miscellaneous equipment for the various types of tests. Outlets for power plugs are mounted in this rear compartment, and also along the sill at the rear of the main bench inside the car. In addition, a receptacle is mounted in one of the rear fenders for plugging in a 110-volt supply for operating the rectifier, and binding posts are mounted on the other fender for connection to the car telephone.

Not only is the car useful in getting out to remote repeater stations for tests, but it proves very helpful, as indicated in Figure 8, when tests are to be made over manholes in

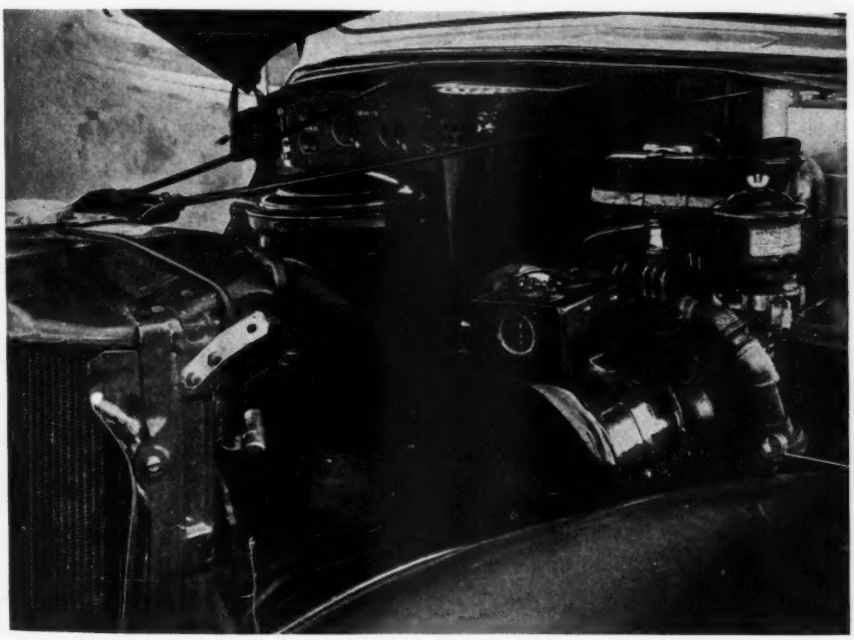


Figure 5

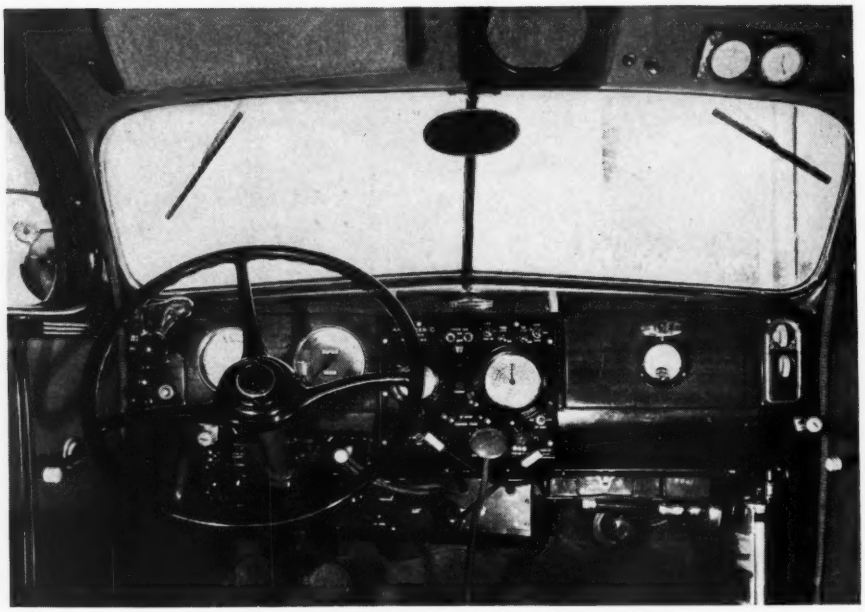


Figure 6

muddy streets. After the test leads have been brought up, as shown in Figure 8, the car is driven over the opening to protect the manhole during the measurements.

Occasionally deep snow prevented the car from being driven directly to the point of test and the more primitive method of transportation shown in Figure 9 was employed.

Since its completion, this mobile laboratory has covered some 25,000 miles, and has been in service 120 working days with temperatures ranging from 10° below zero to 110° above. Most of its life so far, which began in July 1939, has been spent in tests of the coaxial cable between Stevens Point and Minneapolis. In addition, however, it was used for tests on the

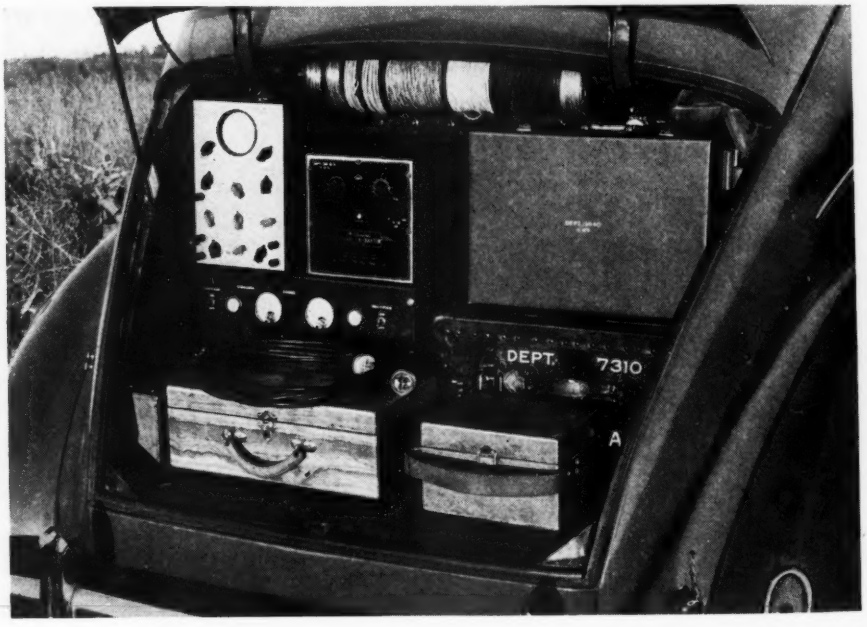


Figure 7

Figure 8

New York-Philadelphia coaxial when the new type L 3-mc system was installed, and, more recently, on the Baltimore-Washington coaxial cable. At Mt. Pocono, Pennsylvania, it was used while making high-frequency measurements on open-wire lines. Its field of use covers a wide range of experimental work that is being carried out on transmission systems.

Figure 9

Directional Selection for Toll-Line Signaling

By H. M. PRUDEN
Switching Development Department

TOLL lines, when in use for talking, are terminated in an impedance that approximately matches that of the line itself so as to keep echoes to unobjectionable values. These proper terminations exist only when a line is connected to a subscriber or operator at both ends. When the line is not so connected at both ends there is no conversation for echoes to disturb. When one subscriber is disconnected the lack of suitable termination has in the past been of no great importance; but with the use of voice-frequency signaling the presence of such an improper termination may affect the reception of the signals by an operator.

Consider, for example, two sections of toll line as shown in block form in Figure 2. It will be assumed that a subscriber served by switchboard A has placed to a subscriber served by switchboard C a call set up through an intermediate switchboard B. At the end of the conversation, after subscriber C has hung up, the operator at switchboard A must ring the operator at switchboard B to notify her to take down the connection. Since subscriber C has hung up, however, the line is not properly terminated at that end, and as a result echoes of the signaling current will return from C to B.

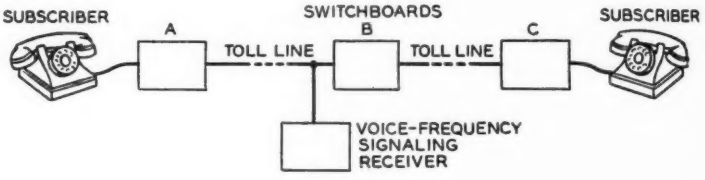


Fig. 2—Two sections of toll line showing voice-frequency signal-receiving device at an intermediate switchboard

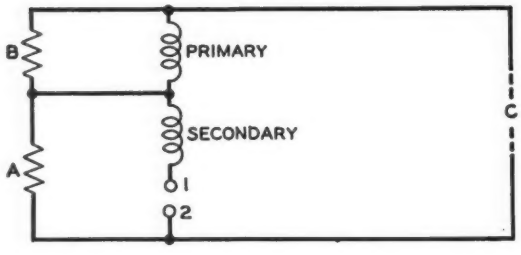


Fig. 1—An arrangement of a transformer and resistances to secure directional-selection action in toll-line signaling

The signaling consists of spurts of 1000-cycle current, and the echoes as received at B will be similar in form but shifted in phase by the time required for the signal to travel from B to C and back. Because of this shift in phase, pulses of the echo will overlap those of the direct signal. In extreme cases there may be almost a complete cancellation of the signal. To avoid such a situation, some arrangement is needed to make the signal-receiving circuit at switchboard B sensitive to signals coming from the direction of A but not from the direc-

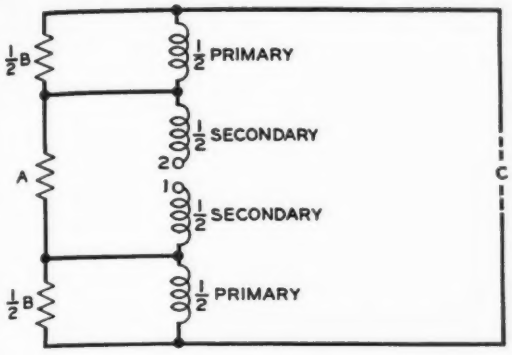


Fig. 3—Modification of Figure 1, to produce a balanced circuit

tion of C. A directional selection circuit developed for this use was mentioned in the RECORD* in connection with the 1000-cycle ringer oscillator.

It consists of two resistances and a transformer arranged as shown schematically in Figure 1. A voltage at C will cause a current to flow through A and B in series, and the voltage drop across B is impressed across the primary of the transformer. The ratio of the voltage drop across B to that across A will be as the ratio of these two resistances, and if the ratio of the number of turns of the secondary winding of the transformer to those of the primary is made the same as the ratio of resistance A to resistance B, the voltage across the secondary of the transformer will be the same as that across resistance A. As a result there will be no potential difference between points 1 and 2. These points could be left disconnected as shown, they could be connected directly together, or a circuit of any impedance could be connected between them without affecting transmission between C and A. A voltage inserted in any other part of the circuit, however, such as arm A, would create a difference of potential across points 1 and 2.

Such a circuit, therefore, may be used to provide directional selection for a voice-frequency signal-receiving circuit. Arm C would represent the line to switchboard C of Figure 2, A would represent the impedance of the line to switchboard A, and the signal-receiving circuit would be connected between points 1 and 2. The circuit must be slightly rearranged first, however, to put it in balanced form. To do this the resistance B and the transformer windings are each divided into two equal parts and arranged as shown in Figure 3. As arranged for application to a toll line, such as at switchboard B of Figure 2, the circuit would be as shown in Figure 4. Signals from switchboard A readily affect the signal-receiving circuit, but echoes from the toll line to switchboard C have no effect on it.

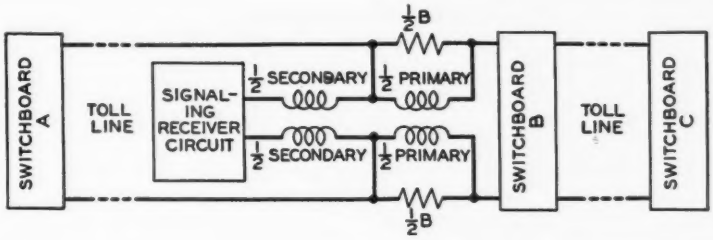


Fig. 4—Directional-selection circuit as applied to the toll circuit of Figure 2

In actual practice these ideal conditions are not attained. There is not a perfect balance between the resistances and the toll line so that some interaction occurs between the toll line toward switchboard C and the signal-receiving device. The impedance balance is sufficiently good, however, to improve considerably the signal-receiving circuit.

*RECORD, *Jan.*, 1941, *p.* 147.

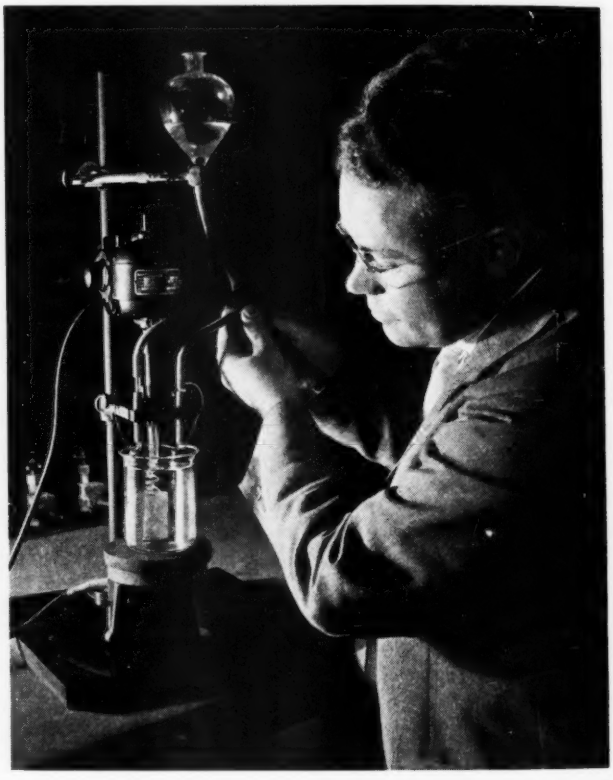
Internal Electro-Analysis

By C. L. LUKE
Chemical Laboratories

WHEN zinc and platinum are dipped into a solution of copper sulphate and connected externally by a wire, the zinc dissolves and metallic copper plates out on the platinum. For over fifty years analytical chemists have utilized this principle in electro-analysis. It is only in recent years, however, that the method has been used extensively in the separation and determination of impurities in alloys. A refinement of this procedure is used by the Laboratories to analyze several types of alloys, including cable sheath. The improved apparatus for the determination of copper and bismuth as impurities in lead cable sheath consists of two lead anodes enclosed in alundum shells and a single platinum gauze cathode, arranged to fit into a beaker. The anodes are made by winding pure lead wire around glass tubing in the form of a compact helix. Good electrical contact is obtained by connecting the three electrodes to a single binding post. The solution of the alloy to be analyzed is placed in the beaker and the anode shells are filled with dilute nitric acid.

Almost immediately the lead anodes begin to dissolve and copper and bismuth are deposited on the platinum gauze electrode in weighable form. Deposition of the metals is speeded by heating and stirring the solution.

With this apparatus as little as one milligram of copper or bismuth may be quantitatively separated from 100 grams of lead or lead alloy. A complete analysis for copper and bismuth can be made in approximately one hour while methods that had been formerly used required six or seven hours for the same determinations.



Contributors to this Issue

J. A. Carr was a graduate from Virginia Polytechnic Institute in 1919 with the degree of B.S. in Electrical Engineering. After spending a year as instructor in Electrical Engineering at Massachusetts Institute of Technology he joined the Development and Research Department of A. T. & T. in 1921. In 1927 he transferred to the Laboratories where he has since been engaged in outside plant development work, particularly on problems relating to aerial systems.

C. L. Luke was graduated in 1930 from the University of Idaho with a degree of B.S. in Chemistry. He joined the Chemical Department of the Laboratories that fall, and since then has been engaged in research associated with analytical chemistry and in the development of chemical methods of analysis.

R. E. King after graduation left the State University of Iowa in 1921 and spent three years teaching at the University of Arkansas. In 1923 he joined the Systems Development Department of the Laboratories. Since then he has been concerned with the design of manual and step-by-step circuits, and is now in charge of a group handling intertoll dialing and step-by-step circuits.

Everett St. John was graduated from Harvard in 1910 with the A.B. degree and he received an S.B. at M.I.T. in 1913. After six months' experience with the Independence Inspection Bureau at Philadelphia he joined The Bell Telephone Company of Pennsylvania. During the war he spent a year and a half in the army as battalion signal officer, then joined the Development and Research Department of A. T. & T., transferring to the Outside Plant Department of the Laboratories in 1927. He has been concerned primarily with the design and development of construction materials and tools for the outside plant throughout his association with the telephone industry.

S. Rosen after graduation from the University of Southern California in 1930 with a B.S. degree in E.E. came directly to the Laboratories where he has been concerned with the development

J. A. Carr

C. L. Luke

R. E. King

of transmission testing apparatus for the maintenance and testing of voice and carrier telephone systems. Among the new toll systems for which testing equipment has been developed are high-quality program systems, open-wire and cable carrier systems, and more recently the coaxial cable carrier systems.

E. St. John

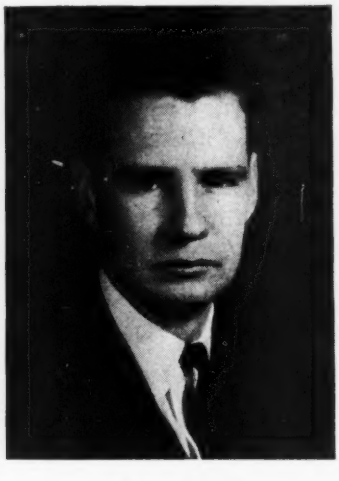
S. Rosen

G. B. ENGELHARDT was graduated from Cornell University in 1930 with the E.E. degree, and shortly after joined the technical staff of the Laboratories, associating himself with the carrier transmission group. In 1939 he completed a series of courses at Columbia University, under the Laboratories' part-time post-graduate study plan, leading to the M.A. degree in physics. His activities at the Laboratories have been concerned chiefly with the design of high-frequency measuring apparatus and, more recently, with field measurements on coaxial cable.

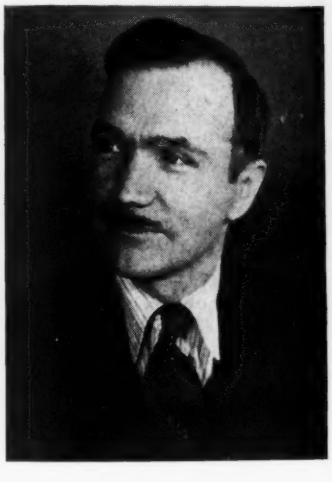
J. B. MAGGIO was graduated in 1935 from Cornell University with the degree of E.E. and received a master's degree in Communications at Harvard University in 1936. He joined the Systems Development Department of the Laboratories that summer, and since then has been associated with the development of repeaters for carrier telephone systems.

H. M. PRUDEN joined the Engineering Department of Western Electric during the summer of 1919 and engaged in laboratory work on voice-frequency signaling. As a member of the Technical Staff since 1924, he has been engaged in development of voice-frequency signaling and dialing systems, and of voice-operated switching devices and control circuits for radio systems.

G. B. Engelhardt



J. B. Maggio



H. M. Pruden